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PREFATORY NOTE TO THE THIRD EDITION.

In the "Supplementary Chapter," appended to the last edition of this work, the author—whose loss the scientific world and his many friends deplore—supplied to his readers a notice of such fossils and geological facts as had accrued during the four previous years. This valuable *resumé* of the more recent discoveries in the Tertiary, Cretaceous, and Wealden deposits has been retained intact in the present edition; but that the reader may be in possession of the latest discoveries, a succinct account of the further progress of geological research has been drawn up by a scientific friend of the much lamented deceased, to whom, also, have been entrusted those sheets of the new edition of the "Medals" which Dr. Mantell left imperfectly revised.

Since the publication of the second edition, the progress of observation has enriched us with many facts concerning the geological history of those southern parts of England, to a notice of which the present volume is devoted; and the many geologists, amateur and professional, who have visited the coasts of Hants, Dorset, and the Isle of Wight, have added numerous valuable fossils to our public and private museums. Some of these have been already

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described and figured, but a large proportion still remain unknown to the reading public.

Before proceeding to speak more especially of the Isle of Wight and the neighbouring coasts, it should be noticed that, by laborious research over both old and new ground, and by careful examination of collected specimens, much light has been thrown on the geological structure of districts hitherto obscure; greater precision has been arrived at in the chronological arrangement of various deposits, and further insight obtained into the pre-adamitic history of the animal and vegetable kingdoms. Of these additions to our knowledge, the journals of the geological societies of London, Dublin, Paris, Berlin, and Vienna are the chief repositories. We shall here refer only to some of the most interesting of the facts that have thrown new light on the science of geology.

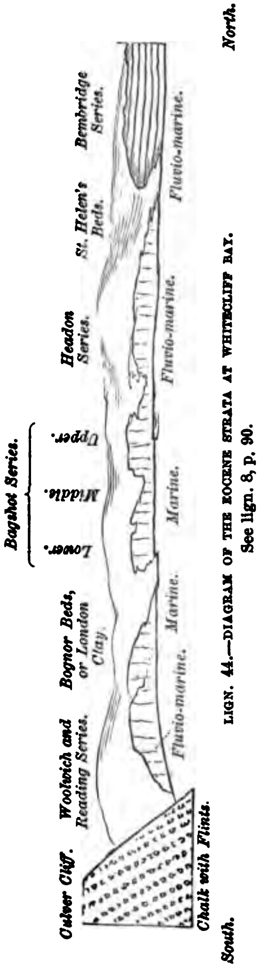
The discovery of traces of large limuloid crustaceans, in the lowest Silurian or Cambrian rocks of Canada and the United States; of fresh-water shells (*anodons*) in the Devonian rocks of the South of Ireland; of tracks and remains of at least two kinds of reptiles in the "old red" of Morayshire; the traces of others in the lower carboniferous or Devonian of Pennsylvania; of reptilian remains in the coal of Scotland and of Nova Scotia; and of land-shells, with the reptiles in the upright tree-stumps, in the latter; of small mammalia in the trias of Wurtemberg; of numerous groups of gasteropoda in the cretaceous rocks of Europe; and of a great variety of dicotyledonous leaves in the lower cretaceous deposits of Aix la Chapelle and elsewhere,—are great facts, illustrative of many an obscure passage in the history of our earth. The noble work devoted to the Palæontology of Bohemia, the ample and highly illustrated volumes of American research, the "Palæontographical Monographs," the "*Paléontologie Française*," the Cambridge "*Fasciculi*," and the Survey "*Decades*" are some of the latest of the great works to which geologists may now turn for the history and portraiture of bygone forms.

Leaving the general consideration of the late acquisitions to our knowledge of ancient faunas and floras, and of the history of their entombment, to the works which especially treat of these subjects, we necessarily limit our observations to those points of interest which are connected with the geology of the Isle of Wight.

I.—CLASSIFICATION OF THE TERTIARY STRATA. (See tabular arrangement, p. 43, and supplemental note, p. 305.)

We have first to notice the important modification which Professor E. Forbes has found necessary to introduce into the classification of the eocene deposits of the northern part of the island. A strict investigation of the distribution and organic contents of the fluvio-marine tertiaries of the Isle of Wight was recently undertaken by this eminent palæontologist; and a general view of the results arrived at will be found in the "Quarterly Journal of the Geological Society," No. 36 (November, 1853).

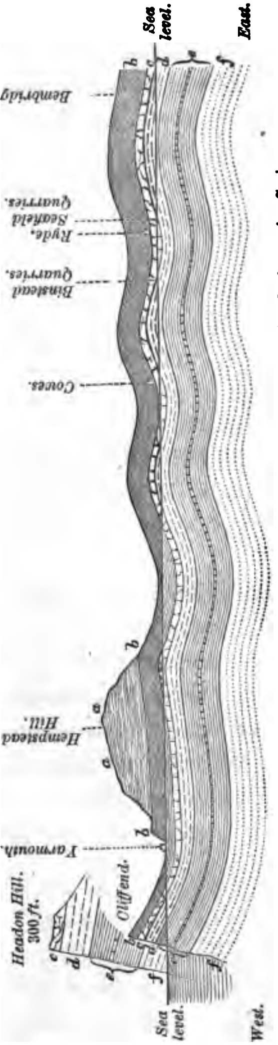
The greater part of the Isle of Wight, north of the great chalk ridge, has been hitherto regarded as composed of eocene beds of freshwater and estuary origin, and of the age of those composing Headon Hill. Professor E. Forbes, however, finds that, contrary to received views, almost all the surface of the island north of the chalk hills is composed of strata higher in the series than



LIGN. 44.—DIAGRAM OF THE EOCENE STRATA AT WHITECLIFF BAY.
See lign. 8, p. 90.

the Headon beds, and intermediate between those and the beds of Hempstead Hill; that all the limestones, except those of Headon Hill itself, belong to the system of these higher strata; that there are two systems of rolls, or undulations, of these beds and of all the tertiaries, one parallel to, and the other at right angles with, the strike of the chalk ridge; that both these undulations affect the chalk itself; that the northern part of Whitecliff Bay (see lign. 44), in the fluvio-marine portion of its beds, does not represent Headon Hill, as has hitherto been maintained, but includes some 200 feet of higher beds; and that over and above the Headon series (lign. 45), there are three sets of beds characterised by peculiar fossils.

At the same time, although there is ample evidence to show that the two upper of these series are the equivalents of the lower miocene of foreign authors, there is also good proof that they all belong to



a, Hempstead Series. *c, Bembridge limestone.* *e, Headon fluvio-marine Series.*
b, Bembridge Marls. *d, St. Helen's Beds.* *f, Headon Sands.*
(See "Quart. Journ. Geol. Soc.," No. 36, p. 260.)

LIGN. 45.—DIAGRAM.—SECTION OF THE UPPER EOCENE TERTIARIES OF THE ISLE OF WIGHT.

the eocene system. Professor E. Forbes proposes the following classification for the fluvio-marine eocene tertiaries of the borders of the Solent:

1. The Hempstead series, 170 feet thick, composed of marls and clays, the uppermost of which are marine. This division, of small superficial extent, is the equivalent of the Limburg beds of Belgium, and, in part, of the Mayence basin, and of the Grès de Fontainebleau. To the level of the middle and lower portions of this series, the so-called miocenes of Malta, and equivalent beds in Barbary, Greece, Italy, Spain, Portugal, and France may now with probability be referred. The distinctness of the vertebrate re-

mains contained in these beds, from those of Binstead and Hordwell, was several years ago indicated by the Marchioness of Hastings. 2. The Bembridge series, about 110 feet thick, consisting of estuary marls, marine beds, and freshwater limestones (those of Bembridge, Sconce, Binstead, &c.), abounding in peculiar fossils, and forming almost the whole of the north shore of the Isle of Wight. This group is the equivalent of the gypsiferous series of the Paris basin. 3. The St. Helen's beds, from 60 to 100 feet thick, variously composed, of estuary and freshwater origin, becoming in part good stone, to the east of Ryde. These beds, possibly representing in part the Grès de Beauchamp, separate the Bembridge from—4. the Headon series, 170 feet or more of strata, forming three divisions long known as the upper freshwater, inter-marine, and lower freshwater. The Hordwell fluvio-marine beds belong to a part of this division.

Mr. Prestwich's continued researches in the structure of the tertiary deposits of the London and Hampshire series have further elucidated the complicated relations of these clays, sands, and ancient gravel beds. The corrected classification of the eocene strata effected by this talented and indefatigable geologist, and the improved nomenclature by which the series is now known, are given in the following table of the superficial and tertiary deposits :—

TABLE OF THE TERTIARY DEPOSITS OF ENGLAND.

PLEISTOCENE:				
	Alluvial; or recent river and estuary deposits	Plumstead Marshes, Lewes Levels, &c.		
	Ancient river and estuary deposits .	Brick-earth at Erith, Grays, Gaytonthorpe, &c.; Hyde Park Gravel, &c.		
	Northern drift; or erratics........	The Boulder-clay, and its sands and gravels.		
PLIOCENE.				
	Bridlington crag, of the Yorkshire coast.			
	Red and coralline crags of Norfolk and Suffolk.			
EOCENE.				
Upper.	Hempstead Series	(See pp. ix.—xii., and ligns. 44 and 45.)		
	Bembridge Series			
Middle.	St. Helen's Beds			
	Headon Series	The richly fossiliferous deposit, of fluvio-marine origin, at *Hordwell* (see p. 121, and supplementary chapter) belongs to this series.		
	Upper Bagshot Series	The well-known *Barton Cliff* (see pp. 120, 124), near Christchurch, exhibits a local argillaceous condition of this part of the series	The white clays and sands near *Corfe* represent these deposits in their extension to the westward	Middle & Upper. London Tertiaries.
	Middle ditto	This division is greatly developed and highly fossiliferous at *Bracklesham Bay*.		
	Lower ditto	A notice of this group, as it occurs in Surrey, is given at page 59.		
Lower.	London Clay	The *Bognor Rock* is a subordinate member of this division		
	Basement-bed of the London clay..	(See supplementary chapter, p. 305, *et seq.*)		Lower.
	Woolwich and Reading Series	Formerly known as the "mottled clays," and "plastic clay"		
	Thanet Sands....................	(See Mr. Prestwich's Memoir on this lowest tertiary group, "Geol. Soc. Journal," 1852, vol. viii., pp. 235, *et seq.*)		

II. SUPERFICIAL DEPOSITS.

Some years since, Mr. Bowerbank noticed the existence of a superficial calcareous bed, containing land-shells of existing species, on the chalk of St. Catherine's Down, and seen in the face of Gore cliff. This deposit, which at first sight might be mistaken for the top of the chalk itself, is a terrestrial or subaërial formation, consisting of the surface-debris, or "run of the hill," on the slope of the chalk-down which once existed, but has been long ago cut away by the sea, and replaced by the present cliff. Similar deposits are common in the Isle of Wight and along the sides of the chalk-hills of Kent and Sussex; and Mr. Trimmer and Professor E. Forbes have lately described another such occurrence at Tolland's Bay. Here, however, local modifications are indicated by the presence of vegetable matter and fresh-water shells, as well as land-shells, in these marly beds.

In making a road for the conveyance of stone for the construction of the Breakwater at Portland in 1851, the fissures in the rock were found to be occupied by a deposit differing from the superficial soils, and containing large rounded boulders, sand, and bones and teeth of the horse, elephant, deer, and other animals. Bones of the wild boar had previously been found in Portland.

III. TERTIARY FOSSILS.

Between Corfe and Wareham, in Dorsetshire, some of the white clay and sandy marls of the pipe-clay pits have been found by Mr. Charles Groves, of the latter town, to be full of dicotyledonous leaves. A portion of the leaf of *Palmacites Lamanonis* has been obtained from these beds by Mr. Groves. The leaves generally are like those of

Alum Bay and Bournemouth. The laminated white clays at Poole Head also abundantly yield similar relics of this ancient flora.

Mr. W. R. Brodie, who has made a fine collection of leaves from the Corfe clays, has also discovered several specimens of insect remains, consisting of coleopterous wing-cases.* These plastic clays belong to the Bagshot series.

In the still older clays of the Reading series, formerly known as the "Plastic Clay," Mr. Prestwich has lately found numerous dicotyledonous leaves, stems, &c. These occurred in limited patches of clay near Reading, and possess a general resemblance to the eocene flora of some parts of Europe, but they have not yet been critically examined.

The eocene corals have been described and figured by MM. Milne Edwards and J. Haime ("Palæontographical Monographs"); few, however, occur at Barton and Bracklesham. The Bryozoa—a more numerous class of coralliform animals, existing under somewhat similar conditions, but essentially different from the corals, and of much higher organisation—are for the most part still unworked. In Dixon's "Geology and Fossils of the Tertiary and Cretaceous Formations of Sussex,"† some of the latter, as well as some corals, are illustrated and described. Mr. Dixon's work gives us a few of the minute shelled animals, known as Foraminifera, and Mr. Prestwich figures a few others, but much yet remains to be done in that quarter.

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* "Quart. Journal Geol. Soc." vol ix. p. 53.

† Quarto, 1850. This valuable work, so indispensable to the geologist who is occupied with the study of the eocene and chalk deposits, deserves more than a passing notice. It demands attention by the artistic skill and care expended on the numerous and beautiful illustrations, the work of Sowerby, Dinkel, and Erxleben; on account of the elaborate palæontological details,—the combined result of the scientific labours of Owen, Egerton, Bell, Lonsdale, Forbes, and Sowerby; and on account of the interesting and learned introductory chapters, containing geological and archæological notices of

Sir C. Lyell has lately published * some important remarks on the distribution of the nummulites, the well-known discoidal shells, which, though generally so much larger than their congeners, are true foraminifera. Particular forms, requiring however considerable discrimination to distinguish them, belong to definite beds and ranges of strata. Thus, one of the smallest of the nummulites (*N. variolarius*) distinguishes a clay-bed at Barton and Stubbington, as well as corresponding beds in the cliffs of Alum Bay and Whitecliff Bay. An allied, but compressed, form characterises a particular clay-bed with green sand, in Alum Bay; whilst a larger and thin species (*N. planulatus*) has been found in the lower beds at Emsworth; and larger and thick species (*N. lævigatus and N. scaber*) have their own separate range, in higher beds of the series, in Alum and Whitecliff Bays.

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the county of Sussex, and some of the neighbouring districts, from the pen of the much lamented Mr. Dixon himself, who was removed from the scene of his labours, and in the midst of an active career, before his self-imposed task was far advanced beyond arranging his splendid collection of tertiary and cretaceous organic remains (since obtained for the British Museum), describing some of his fossils, and superintending many of the plates. This splendid work has thus a most melancholy interest; and, while it serves the useful purposes for which it was projected by its lamented author, it forms a noble monument to a naturalist so prematurely lost,—raised by a band of loving friends, on a basis founded by his own intelligence and industry. Fortunately for the lovers of science, this very interesting and beautiful volume has passed into the hands of Mr. Bohn, and is now published by him at half its original price.

* See "Quart. Journ. Geol. Soc.," vol. viii. p. 334, &c.

Of the mollusca of the tertiary deposits of these districts, Mr. Edwards, Mr. Prestwich, and others have published in their respective memoirs good figures and descriptions; but to the late Mr. Dixon's work, already noticed, we must refer for a large mass of information on this subject, and on the icthyology of the tertiary period; several remains of the larger animals are also figured by Mr. Dixon, but the monographs on the fossil reptiles, by Professor Owen and Professor Bell, afford a compendious history and elaborate illustrations of these most important relics. We must not omit, however, to refer the reader to the beautiful coloured plate of the skull of the Hordwell alligator, in "Charlesworth's Geological Journal."

The eocene tertiaries of England abound with remains of turtles, both of the marine and the freshwater groups of these animals.

"The majority of the eocene chelonites," says Professor Owen,* "belong to the true marine genus *chelone;* and the number of species of these extinct turtles already obtained from so limited a space as the Isle of Sheppy† exceeds that of the species of *chelone* now known to exist throughout the globe."‡

In the "Palæontographical Monograph," 1850, p. 49, after describing the crocodiles of the "London clay proper," from Sheppy and Harwich, Professor Owen proceeds to give, in detail, the structure of the *Crocodilus Hastingsiæ* and *Alligator Hantoniensis*, of Hordwell, and the *Gavialis Dixoni*, of Bracklesham; and, in reviewing the interesting palæontological facts to the elucidation of which his labours have so greatly contributed, the Professor eloquently remarks:—

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* "Monograph on the Eocene Reptiles," 1849, p. 44.

† Seven species from Sheppy, two others from Harwich, and two or three from the Hampshire tertiaries, are described by Professors Owen and Bell.

‡ "All the tropical seas of the world have hitherto yielded no more than five well defined species of *chelone;* and of these only two, as the *Ch. mydas* and *Ch. caouana*, are known to frequent the same locality."—*Ibid.*, p. 44.

> "Crocodiles, gavials, and alligators now require, in order to put forth in full vigour the powers of their cold-blooded constitution, the stimulus of a large amount of solar heat, with ample verge of watery space, for the evolutions which they practise in the capture and disposal of their prey. Marshes with lakes, extensive estuaries, large rivers, such as the Gambia and Niger that traverse the pestilential tracts of Africa, or those that inundate the country through which they run, either periodically, as the Nile for example, or with less regularity, like the Ganges; or which bear a broader current of tepid water along boundless forests and savannahs, like those ploughed in ever-varying channels by the force of the mighty Amazon or Oronooko,—such form the theatres of the destructive existence of the carnivorous and predacious crocodilian reptiles. And what, then, must have been the extent and configuration of the eocene continent which was drained by the rivers that deposited the masses of clay and sand, accumulated in some parts of the London and Hampshire basins to the height of one thousand feet, and forming the graveyard of countless crocodiles and gavials? Whither trended that great stream, once the haunt of alligators, and the resort of tapir-like quadrupeds, the sandy bed of which is now exposed on the upheaved face of Hordwell Cliff?
>
> "Had any of the human kind existed and traversed the land where now the base of Britain rises from the ocean, he might have witnessed the gavial cleaving the waters of its native river with the velocity of an arrow, and ever and anon rearing its long and slender snout above the waves, and making the banks re-echo with the loud and sharp snappings of its formidably armed jaws. He might have watched the deadly struggle between the crocodile and palæothere, and have been

himself warned by the hoarse and deep bellowings of the alligator from the dangerous vicinity of its retreat. Our fossil evidences supply us with ample materials for this most strange picture of the animal life of ancient Britain; aud what adds to the singularity and interest of the restored *tableau vivant*, is the fact that it could not now be presented in any part of the world. The same forms of crocodilian reptile, it is true, still exist, but the habitats of the gavial and the alligator are wide asunder, thousands of miles of land and ocean intervening; one is peculiar to the tropical rivers of continental Asia, the other is restricted to the warmer latitudes of North and South America; both forms are excluded from Africa, in the rivers of which continent true crocodiles alone are found. Not one representative of the crocodilian order naturally exists in any part of Europe; yet every form of the order once flourished, in close proximity to each other, in a territory which now forms part of England."

IV.—FOSSILS OF THE CHALK.

To the palæontological history of the chalk, and its associated galt and greensands of the south-east of England, Sir P. Egerton and Professor Owen have added valuable descriptions and figures of reptiles and fishes; whilst Professor E. Forbes has described a large mass of of the echinoderms; Mr. Sowerby and others, numerous mollusca; Professor Bell, the larger crustacea; Mr. Lonsdale, the corals; Mr. Davidson, the terebratulæ; Mr. Morris, the clionites; Mr. Rupert Jones, the minute entomostraca; and Mr. John Brown has lately figured some of the foraminifera.

V.—WEALDEN FOSSILS.

The Wealden and Purbeck deposits have considerably enriched the collectors who have devoted time and labour to the search for fossils. The novel and gigantic reptile, the pelorosaurus, was first known from the relics found by Mr. Fuller, near Cuckfield, and described by Dr. Mantell, "Phil. Trans." 1850. Mr. Beckles has continued his examination of the Wealden of Hastings and the vicinity; and, besides some remains of the iguanodon, has found and carefully worked out from the rock, at low water, the magnificent *humerus*, *ulna*, and *radius* of the pelorosaurus which were described by Dr. Mantell, in 1852, at the Royal Institution (March 5). Mr. Beckles has also added to his Wealden collection numerous fine fish remains, especially perfect heads and dorsal rays, together with splendid fronds of cycads and ferns, numerous uniones, and other fossils.

The Purbeck marls and limestones had already yielded the remains of a host of insects; but the Wealden proper (which overlies the Purbecks) had, with the exception of one wing (found by Professor E. Forbes in the Hastings series of the Isle of Wight), given no indication of the insect-life of that period.

We have now, however, the pleasure of recording that Messrs. W. R. and H. Binfield, to whose successful search for insect remains in the lias of Gloucestershire and Dorset their cabinets bear ample testimony, have developed from the Wealden strata, at Hastings, St. Leonard's, and in the neighbourhood, numerous specimens of wings and wing-cases of various species of insects. This important addition to our knowledge of the fauna of the Wealden proper was lately worked out by these gentlemen during a short recess from professional labours, and indicates a fine field of research for such as have the requisite eye, tact, and patience for the finding of insect remains.

VI.—PURBECK FOSSILS.

From the Purbeck formation, on the Lulworth coast, Mr. C. Groves, of Wareham, has lately obtained a large portion of the lower jaw of the "Swanage crocodile," (*Goniopholis crassidens*,) see p. 258. It was imbedded in the marls not far above the "cinder bed." Figures and descriptions of some of the fishes of the Purbeck have been given to the scientific world by Sir Philip Egerton.

VII.—OOLITE FOSSILS.

A few bones of crocodilian reptiles have been found by Mr. Neale and others in the Portland oolite, at Portland; a single coleopterous wing-case has been detected by the Rev. Mr. Brodie's practised eye in the Kimmeridge clay of Ringstead Bay;* some new fishes have been found in the black shales at Kimmeridge, together with a fine *sepia* and other interesting fossils, by Mr. Grove, of Wareham; and, lastly, a magnificent paddle of a very large *pleiosaurus*, from the Kimmeridge clay of the Isle of Purbeck, has been deposited in the Dorchester Museum.

Thus have surveyor and collector, geologist and palæontologist, each contributed during the few past years the results of their untiring labours to the building up of the yet imperfect temple of science. The solid frame-work and the delicate adornment have equally advanced under the care of the naturalists devoted to the study of geological phenomena; whether working out the history of a mountain-range, or noting the structure of a sand-bank; whether exhuming mighty bones, or studying the almost invisible relic of the animalcule. These later additions to our knowledge still confirm the philosophical generalisations so clearly laid down in the "Retrospective Summary," at page 334, and in the body of the work, at page 293; they enable us to add many an organic form to our lists of the extinct faunas and floras of ancient lands and seas, and sometimes add antiquity to the genealogical descent of a species, a genus, or a family; yet they offer no contradiction to the general statements with regard to the history of the globe and its inhabitants, so lucidly and eloquently treated by the lamented author of the "GEOLOGY OF THE ISLE OF WIGHT."

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* "Quart. Journ. Geol. Soc.," vol. ix., p. 51.

T. R. J.

PREFACE.

THE ISLE OF WIGHT is described by Sir Walter Scott, as "that beautiful Island, which he who once sees never forgets, through whatever part of the wide world his future path may lead him." And if this favoured spot deserve such an encomium from the Poet, and the ardent admirer of beautiful and picturesque scenery, it possesses stronger claims to the attention of the natural philosopher, for the strata of which it is composed present phenomena of the highest interest, and abound in those "Medals of Creation," which elucidate some of the most important revolutions recorded in the early pages of the earth's physical history.

The geological characters of the Isle of Wight are well known to the scientific inquirer through the labours and publications of Sir HENRY ENGLEFIELD, Mr. THOMAS WEBSTER, and other able observers; while the beautiful models of the stratification of the Undercliff, and southern coast, constructed by Captain IBBETSON, and the collection of fossils accompanying them, which are exhibited in the Polytechnic Institution of London, afford an instructive exposition of the strata and organic remains of this interesting district.

But notwithstanding these admirable illustrations, I may venture to affirm, that the Geology of the Island is but little known or regarded by the majority of the intelligent persons who every season flock by thousands to its shores, and, rapidly traversing the accustomed routes, visit the picturesque localities noted in the numerous hand-books, and take their departure, without suspecting that they have been travelling over a country rich with the spoils of nature, and teeming with objects of the highest interest to the instructed observer.

Even the inhabitants, with but a few honourable exceptions, manifest an extraordinary degree of apathy in everything relating to the Geology of the Island. In vain will the stranger seek for public collections illustrative of its physical structure and fossil remains. In one week it would be easy for a practical geologist to collect a more instructive series of specimens than is contained in the Museum of the Scientific Institution of the capital of the Island—Newport.

Conceiving that this indifference and neglect may, in a great measure, be attributable to the want of a popular guide to the geological phenomena of the Island, for the well informed but unscientific visitors, I have attempted to supply the deficiency in the present volume; which is designed to afford a familiar explanation of the physical structure of the Isle of Wight and the adjacent coast of Dorsetshire, and of the organic remains which abound in many of the localities that will come under our notice in the course of these Excursions.

For the convenience of the geologist, and of others who may be desirous of investigating the stratification of the Island in detail, a list is subjoined of the principal works and memoirs hitherto published on the subject, and of which a general review is comprised in the following pages.

January, 1847.

ADVERTISEMENT TO THE SECOND EDITION.

ALTHOUGH no effectual steps have yet been taken to establish in the Isle of Wight a public collection of its natural productions, yet so many interesting fossils from various parts of the Island have been discovered and submitted to my examination since the publication of the former edition of this volume, that I have reason to conclude my humble attempts to direct attention to the geological phenomena of the district have not been wholly fruitless.

From the want of a local Museum, numerous valuable specimens have, however, been dispersed, and are now irretrievably lost to science; yet the facts described in the Supplementary Chapter are sufficient proofs of the important acquisitions relating to the ancient physical history of the globe, that may be gathered by individual research, and of the facility with which an extensive collection illustrative of the Geology and Palæontology of the Island might be made, if but few of the intelligent and wealthy inhabitants would combine to effect so desirable an object.

That the illustrious PRINCE, who so zealously encourages every attempt to promote the advancement of Art and Science, would extend his patronage to such an Institution there can be no doubt; and I still indulge the hope that the "Beautiful Island" will possess ere long, in a well-arranged Museum of its natural productions, a new and powerful attraction to visitors and tourists, and an inexhaustible source of intellectual gratification to the inhabitants.

G. A. M.

December, 1850.

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"If we look with wonder upon the great remains of human works, such as the columns of Palmyra, broken in the midst of the desert; the temples of Pæstum, beautiful in the decay of twenty centuries; or the mutilated fragments of Greek sculpture in the Acropolis of Athens, or in our own museums, as proofs of the genius of artists, and power and riches of nations now passed away; with how much deeper feeling of admiration must we consider those grand monuments of nature which mark the revolutions of the globe; continents broken into islands; one land produced, another destroyed; the bottom of the ocean become a fertile soil; whole races of animals extinct, and the bones and exuviæ of one class covered with the remains of another, and upon the graves of past generations—the marble or rocky tomb, as it were, of a former animated world—new generations rising, and order and harmony established, and a system of life and beauty produced out of chaos and death; proving the infinite power, wisdom, and goodness of the GREAT CAUSE of all things!"

SIR H. DAVY.

HINTS FOR VISITORS

TO

THE ISLE OF WIGHT.

As the tourists from Southampton, Gosport, Portsmouth, &c., generally land either at Ryde or Cowes, the following Excursions are so arranged as to afford an explanation of the geological phenomena, when proceeding from either of those towns, to the eastern or western extremity of the island. But as the preliminary sketch of the Geology of the south-east of England (p. 40,) conveys a general idea of the structure of the country, it is immaterial at what place the observer may commence his explorations.

"Brannon's Travelling Map of the Isle of Wight" will be found very convenient for reference; and "Barber's Picturesque Illustrations," which contains numerous excellent engravings of the most interesting scenery, will serve as a beautiful illustrative atlas to our geological descriptions.

COWES.—In the vicinity of this town there are no interesting sections of the strata easily accessible to visitors, nor any locality rich in organic remains. The blocks of freshwater limestone scattered along the shore contain the usual fossils of the tertiary fluvio-marine deposits.

RYDE.*—The freshwater tertiary strata are fully displayed in the vicinity of Ryde. A delightful walk to the village of Binstead conducts to several quarries of the limestone which is extensively used as a building material along the northern district of the Island. Fine specimens may here be collected of fossil freshwater shells (see Pl. I. and II.); and these quarries are worth visiting again and again, for the chance of finding teeth or bones of mammalia, similar to those which occur at Montmartre, near Paris, and of which some relics have been discovered at Binstead, by Mr. Pratt and Mr. Prestwich. (See Pl. II.) From Ryde, the *Tertiary strata* at Brading, Bembridge, St. Helen's, and White Cliff Bay—the *Chalk* at Culver Cliffs—and the *Wealden* deposits at Sandown Bay—may be visited; and afterwards the *Firestone*, *Galt*, and *Greensand* of the Chalk formation at Shanklin, and along the Undercliff.

If the direct road from Ryde to the western extremity of the Island is taken, we pass by several quarries at Binstead, on the road-side; and traverse the interior of the Island, by that picturesque spot, Wooton Bridge, to Newport, and from thence to Alum Bay. Grove's hotel, on the summit of the hill, is an excellent resting-place for the visitor desirous of examining the highly interesting tertiary strata at Headon Hill and Alum Bay. From Cowes, by Newport, the same route may be taken.

By the steamers we may proceed to Yarmouth, which is the best locality for surveying the western parts of the Island. The tertiary strata at Colwell Bay, Headon Hill, and Alum Bay, are within a moderate distance;* and magnificent sections of the chalk are displayed from the Needles, along Scratchell's Bay to Freshwater Gate. (See Pl. X.) From the latter place excursions may be made either over Afton and Shalcomb Downs (see Pl. XI. and XII.), or under the cliff, by Compton Bay to Brook Point, where the fossil forest of the Wealden is exposed. From Brook the Atherfield coast-guard station may be visited, where there is a foot-track down the Cliff to the sea-shore, near the junction of the freshwater beds of the Wealden with the marine strata of the Greensand above; a locality which the researches of Dr. Fitton have made classic ground to the geologist.

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* At Ryde information may be obtained as to the best localities, and mode of visiting them, of Mr. G. Fowlstone, lapidary, 4, Victoria Arcade, who has generally on sale a choice collection of pebbles and other specimens, the *genuine productions* of the island. Many of the so-called Isle of Wight pebbles are either German or Scotch agates!

A pedestrian tour round the Island may be accomplished in ten or twelve days, and the principal localities visited, and a good collection obtained of the organic remains peculiar to each formation. The following notes of a trip made last summer by my young friends, the Messrs. Gladstone, of Stockwell, may perhaps be useful to some of my readers.

Monday.—By railway from London to Southampton—to Cowes by steamer. Examined the blocks of freshwater limestone on the sea-shore, and collected specimens of *Limneus* (Pl. I. figs. 3, 4), *Planorbis* (Pl. I. fig. 1), and other shells. By coach to Newport; walked to Carisbrook Castle, and, after a stroll over the ruins, examined the chalk pits of Mountjoy.

Tuesday.—Rode to Calbourne, and visited the quarries of freshwater limestone. Walked to Grove's hotel on the summit of the hill, over Alum Bay. In the afternoon strolled to the sea-shore at the foot of Headon Hill, and along Alum Bay; collected numerous fossil shells from the freshwater strata at the former, and marine shells from the London clay at the latter place.

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* Mr. Butler, of the Bugle Inn, Yarmouth, an intelligent practical ornithologist, will afford the stranger the requisite information as to the most interesting localities, and the best means of visiting them. He has often accompanied me in my geological rambles.

Wednesday.—Walked over the Downs to Freshwater Gate; and from thence by Afton and Shalcomb Downs to Brook Point, where we examined the fossil forest of the Wealden. Proceeded by Brixton through Atherfield to Blackgang Chine; the unfavourable state of the weather prevented our reaching Atherfield Point.

Thursday.—Proceeded along the Undercliff by St. Lawrence, Ventnor, Bonchurch, and Luccomb Chine, to Shanklin; stopping occasionally to collect specimens, and enjoy the scenery. Went along the shore to Dunnose Point, and gathered numerous fossils, among which were some leaflets of the Wealden fern (*Lonchopteris Mantelli*), associated with *terebratulæ* and *trigoniæ*. Slept at Shanklin.

Friday.—Walked by the sea-side to Sandown Bay, where we collected many Wealden fossils; proceeded to Brading.

Saturday.—Visited the Culver Cliffs and White Cliff Bay, and obtained many fossils similar to those from the north-western part of the Island. In the evening walked to Ryde.

Monday.—Went to the quarries at Binstead, and collected several good specimens of fossil freshwater shells of the same species as those at Calbourne. Left for Portsmouth; visited the Dock Yards; to London by the late train.

These young gentlemen went unattended, and without any previous knowledge of the Isle of Wight, except what they had gathered from conversations with me, and returned home with an instructive series of the organic remains of the island; thus affording a practical illustration of Mrs. Barbauld's admirable story of "Eyes and No Eyes."

DESCRIPTION OF THE PLATES.

ORGANIC REMAINS.

Pl. I.—FOSSIL SHELLS, from the *freshwater Eocene* strata of the Isle of Wight, at Headon Hill, Calbourne, Shalfleet, and Binstead.

Pl. II.—Fossil shells from the same deposits; and teeth of *Mammalia*, from the quarries at Binstead, near Ryde.

Pl. III.—Fossil shells from the *marine Eocene* deposits, at Alum Bay, Colwell Bay, &c.

Pl. IV.—Fossil shells from the *Greensand* strata of the Chalk formation. The *Perna Mulleti*, a very characteristic shell, is here figured.

Pl. V.—Other shells from the *Greensand:* the large *Scaphite*, which occurs in this division of the cretaceous deposits, is represented on a small scale, in Fig. 11.

Pl. VI.—A few characteristic freshwater shells from the *Wealden* strata.

Pl. VII.—A plan of the Geological structure of the Isle of Wight; by Professor John Phillips.

Pl. VIII.—ALUM BAY, FROM HEADON HILL.

This view is taken from the side of the hill, where the pathway from the summit of the Downs winds along the edge of the cliff, to the foot-track that conducts to the sea-shore. In this sketch the nearly vertical Chalk strata, which terminate in the isolated wedge-shaped masses, called "The Needles," are alone visible. The variegated tertiary sands and clays, that impart so remarkable an aspect to Alum Bay from the sea, form the vertical face of the cliff on the left hand of the observer, but are not seen in this sketch. The Isle of Portland appears looming in the remote distance.

Pl. IX.—TERTIARY STRATA OF HEADON HILL, FROM THE SEA.

The face of the cliff here represented exhibits a natural section of a series of tertiary strata, principally of freshwater origin, which have been thrown down, unconformably to the marine deposits in the adjacent cliff of Alum Bay; for while the latter are vertical, these are nearly horizontal. The footpath runs from the Downs to the sea-shore, along the steep slope, forming the north side of the chasm that separates Headon Hill from Alum Bay; its situation is indicated by the two upper figures.

Pl. X.—CHALK CLIFFS ON THE WEST OF FRESHWATER GATE.

The face of the cliffs to the west of the landing-place at Freshwater Gate presents a nearly perpendicular section, 200 feet high, of the Upper Chalk, with numerous layers of flint, the strata being highly inclined. At the base of the projecting cliff is the entrance to a large cavern, formed by the continued action of the surge on the chalk rock.

Pl. XI.—VIEW OF THE CLIFFS FROM BEYOND COMPTON CHINE TO BROOK POINT, AS SEEN FROM NEAR THE BASE OF AFTON DOWN.

The foreground is part of the southern slope of Afton

Down, and consists of the flinty chalk. The pathway winds over the brow, and leads to Compton Chine, down which a rude foot-track conducts to the beach. The strata at this point are the cretaceous ferruginous sands, which emerge from beneath the Galt on the west, and are succeeded on the east by the Wealden deposits; but the face of the cliffs along the westernmost part of Compton Bay is not seen in this sketch. The strata forming the cliffs, shown in this view, are the sands, clays, and shelly limestones of the Wealden.

The first point of land jutting into the sea, and terminating in ledges or reefs, is the western boundary of Brook Bay; at the base of the cliff is the fossil forest of the Wealden. The limits of Brook Bay are shown by the head-land beyond, which is the eastern point. The farthest land on the shore is the Cliff near Blackgang Chine. Saint Catherine's Hill rises in the remote distance.

Pl. XII.—BLACKGANG CHINE FROM THE SEA-SHORE, LOOKING NORTH-EAST.

This view presents a fine natural section of the strata composing the Greensand group of the Chalk formation. The highest point in the distance is the escarpment of Saint Catherine's Hill, which is 830 feet above the level of the sea. The upper part of the cliffs is composed of alternating strata of greenish grey sand and sandstone; from the wearing away of the friable layers the beds of hard grit become prominent, and appear in this view as very distinct, and nearly horizontal, bands of rock. The cliff below the thin bed of ironstone grit, from which the cascade issues, is formed of dark-coloured clay, alternating with ferruginous sand and grit. The long-continued action of the water has produced a deep chasm, or chine, and the stream falls in a nearly perpendicular column from a height of seventy feet to the base of the cliff, whence it rushes to the sea.*

Pl. XIII.—Vertical Chalk Strata on Brading Down.

This sketch shows the vertical position into which the originally horizontal chalk strata have been thrown, in the central range of downs. The layers of shattered flint nodules render the displacement of the strata obvious to the most casual observer.

Pl. XIV.—Cliffs of Wealden Clays in Compton Bay, seen from the west.

In this view the nearest cliffs are formed by the clays, sands, and shales of the Wealden, which constitute the cliffs and ledges to beyond Brook Point, and almost as far as Atherfield. The inclined position of the strata is well shown in the sketch.

The horizontal layer on the top of the cliffs is an accumulation of drifted materials, composed of gravel, clay, and loam, which in some places is from ten to twelve feet thick, and contains bog-wood, hazel-nuts, &c. The nearest point of land is Bull-face Ledge; and that further to the east is Brook Point, where the fossil forest forms ledges that stretch far out to sea. The extreme land is the easternmost point of Brook Bay. The view given in Plate XI. shows the continuation of the cliffs from beyond Bull-face Ledge to the western point of Brook Bay.

Pl. XV.—Culver Chalk Cliffs, from the sea.

In this sketch (reduced from Mr. Webster's) is shown the eastern promontory of the Isle of Wight, which is a vertical section of the chalk range, that extends from this point, in a westerly direction, right through the island to the Needles. The interrupted lines denote the layers of flint, and distinctly exhibit the highly-inclined position of the strata towards the north. The dip varies from 50 to 70 degrees. The distance on the left is Sandown Bay; on the right are seen the eocene strata of White-cliff Bay.

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* The picturesque character of this interesting spot is admirably shown in the views given by Sir Henry Englefield, and by Mr. Barber, and also in the spirited vignettes on the embellished letter paper published by the booksellers in the island.

VIEWS ON THE COAST OF THE ISLE OF PURBECK:

Reduced from the beautiful Engravings by Mr. Webster, in Sir Henry Englefield's Isle of Wight.

Pl. XVI.—VIEW OF THE DORSETSHIRE COAST, FROM WORTH BARROW, LOOKING WESTWARD.

This interesting view of the Dorsetshire coast, looking towards the west, is taken from Worth Barrow, a tumulus situated near the summit of a very high precipice of the chalk range. The bay included between the foreground and the detached rocks in the sea is Worth Barrow Bay; the road down to which is seen just beyond the projecting point of the chalk cliff. The rocks bounding the bay are the Purbeck beds, covering the *Oolite*. The long hill in the middle of the view is the Swine's-back, beyond which is West Lulworth Cove. The Isle of Portland appears in the distance, united to the main land by the Chesil Bank. Weymouth road is indicated by the vessels at anchor.

The deep sinuosities made in the cliffs along this coast by the inroads of the sea are well shown in this sketch.*

Pl. XVII.—LULWORTH COVE, FROM THE WEST.

Lulworth Cove is an almost semicircular bay, formed by the action of the sea on the vertical strata which constitute this part of the coast; and in the section thus exposed the series of rocks, from the chalk to the oolite inclusive, may be traced. A small part of the chalk cliff is seen on the left of the Cove, and from that to the entrance, where the oolite appears, the intermediate strata occur. The upright rocks in the sea near the foreground are masses of the Purbeck beds on this side of the bay, while similar blocks appear on the opposite bar. The argillaceous strata on the side of the hill are curiously contorted from lateral pressure.

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* Sir Henry Englefield's Isle of Wight, p. 183.

Pl. XVIII.—West Lulworth and Cove.

The village of West Lulworth is situated in a deep valley, formed by an interruption of the chalk range that extends from Handfast Point, through Corfe Castle, to the coast. The Cove, which has been produced by the erosive action of the sea on the chalk cliffs, is about 1,300 feet in diameter, and vessels of a hundred tons burthen may at all times remain here in perfect security.

The hill immediately above the village is the termination of the long ridge called the Swine's-back, which is half cut into the Cove and presents a lofty precipitous chalk cliff. St. Adhelm's head is in the remote distance; the nearer headland, seen above the Cove, is Gad Cliff.

Pl. XIX.—Durdle Cove.

In Durdle Cove the series of deposits, from the upper flinty chalk to the Portland oolite, is exposed in a nearly semicircular bay walled in by vertical sections of these strata. The chalk appears on the right, forming the high cliff termed Bat's Corner; and in passing from thence round the bay, the *Chalk marl, Firestone, Galt, Greensand, Wealden,* and *Purbeck strata,* may be successively traced to the *Portland oolite,* which terminates the point on the left of the sketch. The natural arched rock, called Barn Door, at the entrance of the Cove, consists of Portland limestone.

Pl. XX.—GEOLOGICAL MAP OF THE ISLE OF WIGHT.

Each of the three *Formations*, or principal groups of deposits, of which the Isle of Wight is composed, is defined by a separate colour.

The *pink* denotes the tertiary *Eocene* strata; the shaded parts indicate the London clay, and other marine beds, in which but few, if any, freshwater fossils occur.

The *blue* marks the *Chalk;* the chief subdivisions of this formation, namely, the *Firestone, Galt,* and *Greensand,* being defined by a difference in the lines of shading.

The *sienna* indicates the *Wealden* deposits, which appear in the bays on the east and west of the promontory of the Undercliff.

⁂ For the original sketch of the Geological Map, and for the drawings of Organic remains, I am indebted to the kindness of Professor Woodward, of the Agricultural College, Cirencester.

The lignographs are by Mr. James Lee, of Prince's Square, Kennington Common.

"To discover order and intelligence in scenes of apparent wildness and confusion, is the pleasing task of the geological inquirer."

DR. PARIS.

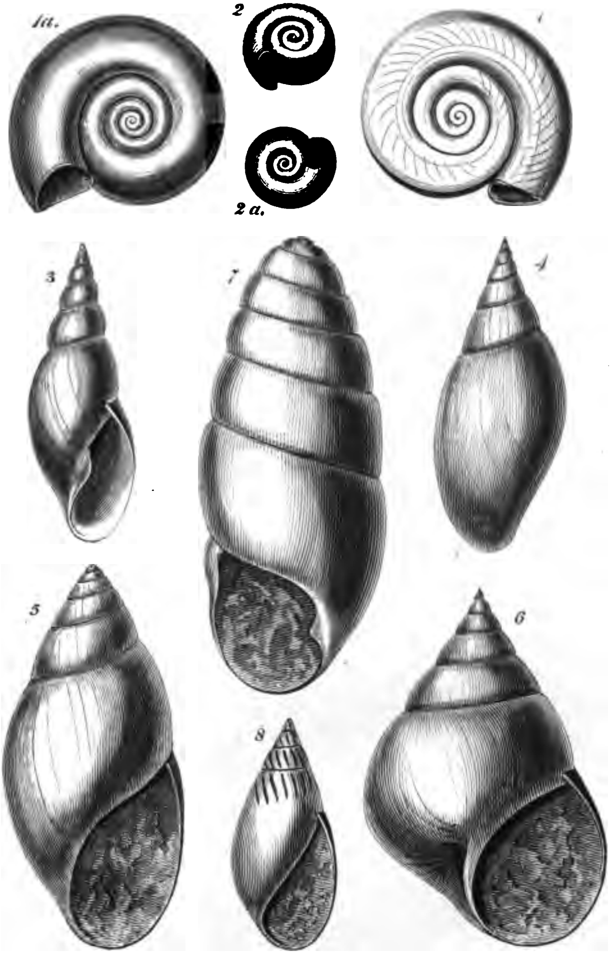
DESCRIPTION OF PLATE I.

FOSSIL SHELLS FROM THE FRESH-WATER EOCENE DEPOSITS.

Fig. 1^{a}.—*Planorbis euomphalus;* the underside.
1.—The same shell on the upper side; from Calbourne.
2.—*Planorbis cylindricus;* Calbourne.
2^{a}.—*Planorbis obtusus;* Shalfleet.
3.—*Limneus longiscatus;* Binstead.
4.—*Limneus fusiformis;* Headon Hill.
5.—*Limneus maximus;* Calbourne.
6.—*Paludina angulosa;* Calbourne.
7.—*Bulimus ellipticus;* Binstead.
8.—*Bulimus costellatus;* Shalfleet.

These fossil shells occur in the limestone and marls at Headon Hill, and in the quarries at Dodspits, Shalfleet, Calbourne, and Binstead, near Ryde. The *Planorbis* and *Limneus* are the most abundant genera; and casts of the common species may be seen in profusion in the cream-coloured limestones used in the walls of cottages, barns, &c., in the northern parts of the Island.

Pl. I.



FOSSIL SHELLS FROM THE FRESH-WATER EOCENE STRATA OF THE ISLE OF WIGHT.

DESCRIPTION OF PLATE II.

FOSSIL SHELLS AND TEETH OF MAMMALIA, FROM THE FRESH-WATER EOCENE DEPOSITS.

SHELLS.

Fig. 1.—*Potomomya gregaria*; from Headon Hill.

This shell is described by Mr. Sowerby in Mineral Conchology as Mya gregaria. The genus *Potomomya*, (river mussels), comprises those species which inhabit rivers only, and are not found in estuaries and brackish waters.

2.—*Potamides concavus*; Headon Hill.
3.—*Melanopsis fusiformis*; Headon Hill.
4.———— *brevis*; Headon Hill.
5.—*Neritina concava*; Colwell Bay.
6.—*Melanopsis carinata*; Colwell Bay.
7.—*Helix globosus*; Shalfleet.
8.—*Potamides plicatus*; Headon Hill.
9.———— *ventricosus*; Headon Hill.

MAMMALIAN REMAINS.

10.—Upper canine tooth of *Anoplotherium commune*; from Seafield, near Ryde.
11.—The grinding surface of an *upper molar*, of *Palæotherium medium*; from Binstead.
12.—One side of the lower jaw of *Palæotherium minus*, with five teeth; from Seafield.*
13a.—A tooth of *Dichobune cervinum*, from Binstead.
13.—The grinding surface of fig. 13a.

With the exception of the gigantic snail-shell, fig. 7, the fossil shells here delineated are abundant at Headon Hill, and in the clays and marls at Colwell Bay. The Mammalian remains are of excessive rarity, and have hitherto only been found in the quarries near Ryde, and at Headon Hill.

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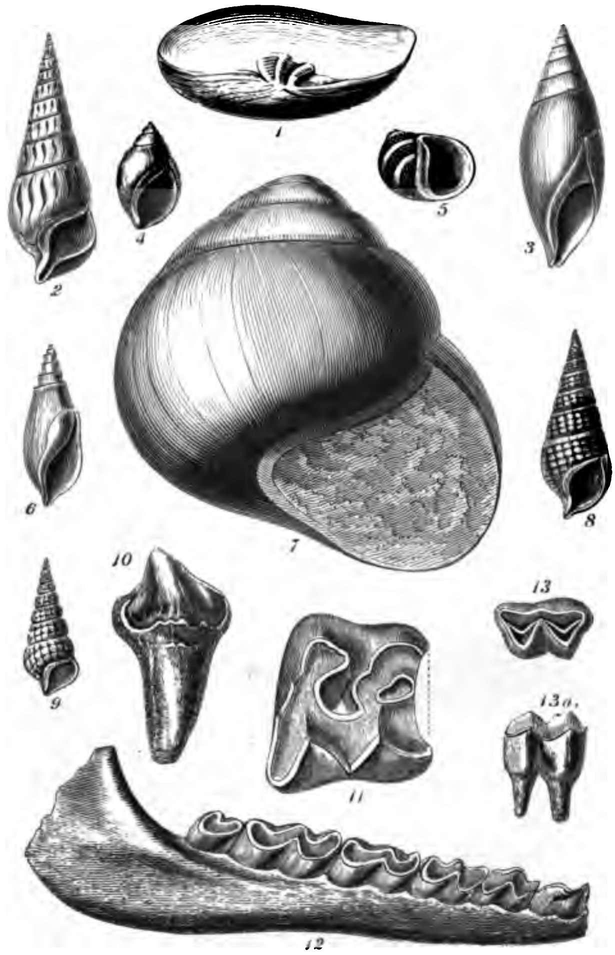
* See "British Fossil Mammals," p. 323.

Pl. II.



FOSSIL SHELLS AND MAMMALIAN REMAINS, FROM THE FRESH-WATER STRATA OF THE ISLE OF WIGHT.

DESCRIPTION OF PLATE III.

FOSSIL SHELLS FROM THE MARINE EOCENE DEPOSITS.

Fig. 1.—***Psammobia solida***, the valves united; from Headon Hill.

1a.—The inner aspect of one of the shells of the same.

2.—***Corbula cuspidata***, the united valves. White Cliff Bay.

2a.—The inner aspect of one of the shells of the same species.

3.—***Ditrupa plana***; Alum Bay.

This ***pteropodous mollusk*** is abundant in the sandstone rock, that overlies the mottled clays which intervene between the chalk and the upper eocene deposits.

4.—***Ancillaria subulata***; Alum Bay.

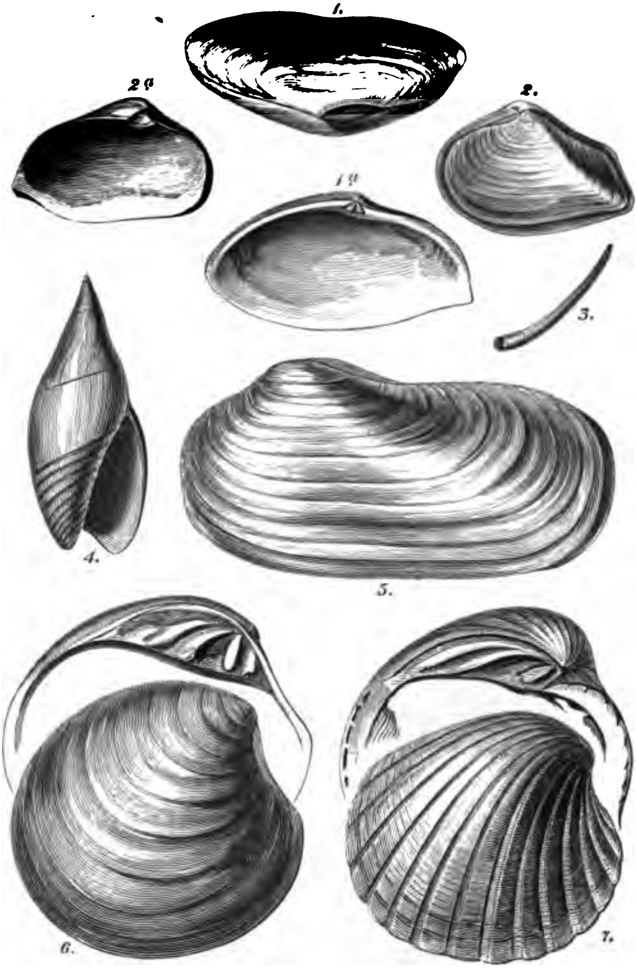
5.—***Panopæa intermedia***; Alum Bay.

6.—***Cytherea incrassata***; Colwell Bay.

7.—***Cardita planicosta***, half the natural size; Alum Bay.

These shells are abundant in most of the localities of the marine tertiary clays, both in the Island, and on the opposite coast of Hampshire and Sussex. The *Panopæa intermedia* (fig. 5), is a well-known shell in the Bognor Rocks; and the *Cardita planicosta* (fig. 7), occurs in profusion in the clay at Bracklesham Bay, in Sussex. The *Cytherea incrassata* (fig. 6), is found in a sandy clay at Colwell Bay, almost as perfect and fresh as if recently left by the sea.

Pl. III.



FOSSIL SHELLS FROM THE MARINE EOCENE STRATA OF THE ISLE OF WIGHT.

DESCRIPTION OF PLATE IV.

FOSSIL SHELLS FROM THE LOWER GREEN-SAND DEPOSITS.

Fig. 1.—*Corbis corrugata*, from the sand-rock, Atherfield: the figure is one-half the size in linear dimensions of the original.

2.—*Trigonia caudata;* from the sand-rock, Atherfield.

3.—*Gervillia anceps;* from the Cracker Rocks, Atherfield. *a*, denotes the markings of the hinge, which are seen in consequence of the valves being slightly displaced. It is represented half the size linear, of the original. These shells are often much larger, and more elongated than in the figure.

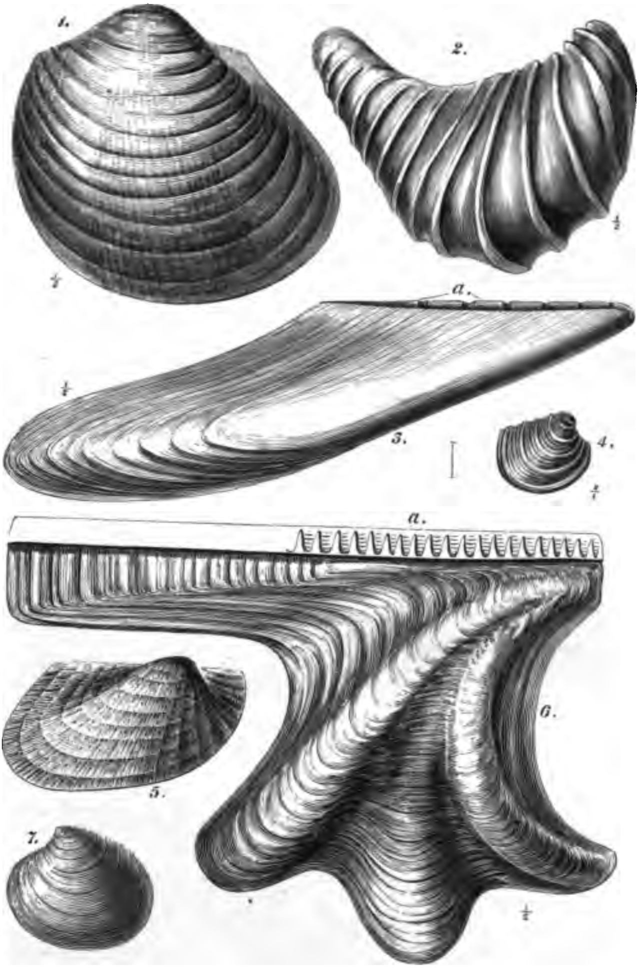
4.—*Venus striato-costata;* a small shell, common in the Cracker Rocks at Atherfield; the figure is twice the size of the original in linear dimensions.

5.—*Arca Raulini;* from the sand-rock, Atherfield.

6.—*Perna Mulleti;* from the lower beds of sand in junction with the Wealden; Sandown Bay. The figure is but half the size of the original. *a*, the structure of the hinge; by comparing this figure with *a*, figure 3, the difference of the hinge in the genera *Perna* and *Gervillia* will be recognised. This large and remarkable shell is highly characteristic of the lower beds of the Green-sand.

7.—*Venus parva;* from Shanklin Cliff.

Pl. IV.



FOSSIL SHELLS FROM THE GREEN-SAND STRATA OF THE ISLE OF WIGHT

DESCRIPTION OF PLATE V.

FOSSIL SHELLS FROM THE LOWER GREEN-SAND DEPOSITS.

Fig. 1.—*Thetis minor;* from the ferruginous sand-rock at the base of Shanklin Cliff.

2.—Another view of the same, to show the beaks and hinge-line.

3.—*Gryphea sinuata;* represented one-fourth the natural size; it is often found much larger. From the Green-sand at Shanklin, Ventnor, Sandown, &c.

4.—*Tornatella albensis;* from the Cracker Rocks, Atherfield.

5.—*Terebratula sella;* an abundant shell in the sand at Atherfield.

6.—*Nucula scapha;* from the sand-rock, Atherfield.

The three following shells are imbedded in a fragment of the Crackers' Rock, from Atherfield.

7.—*Natica rotundata.*

8.—*Pterocera retusa.*

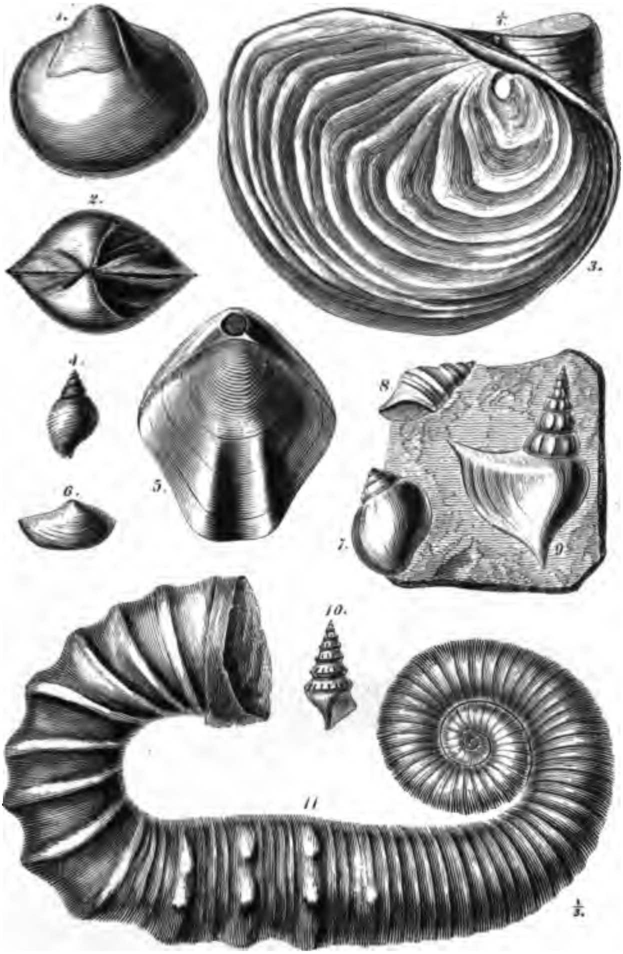
9.—*Rostellaria Robinaldina.*

10.—*Cerithium turriculatum;* from Atherfield.

11.—*Scaphites gigas;* from Atherfield. The figure is but one-third the size, linear, of the original.

This fossil is often found two feet in length, associated with Ammonites equally gigantic.

Pl. V.



FOSSIL SHELLS FROM THE GREEN-SAND STRATA OF THE ISLE OF WIGHT.

DESCRIPTION OF PLATE VI.

FOSSIL SHELLS FROM THE WEALDEN DEPOSITS.

Fig. 1.—*Unio Valdensis*; from the fossil forest at the base of the cliff at Brook-point. A young shell; the figure is two-thirds the natural size in linear dimensions. The uppermost figure gives the inner view of the same shell, to show the hinge and muscular imprints.

2.—*Paludina elongata*, in hard clay, from near Brook-point; large slabs of laminated clay covered with this species, associated with myriads of Cyprides, are continually laid bare by the inroads of the sea.

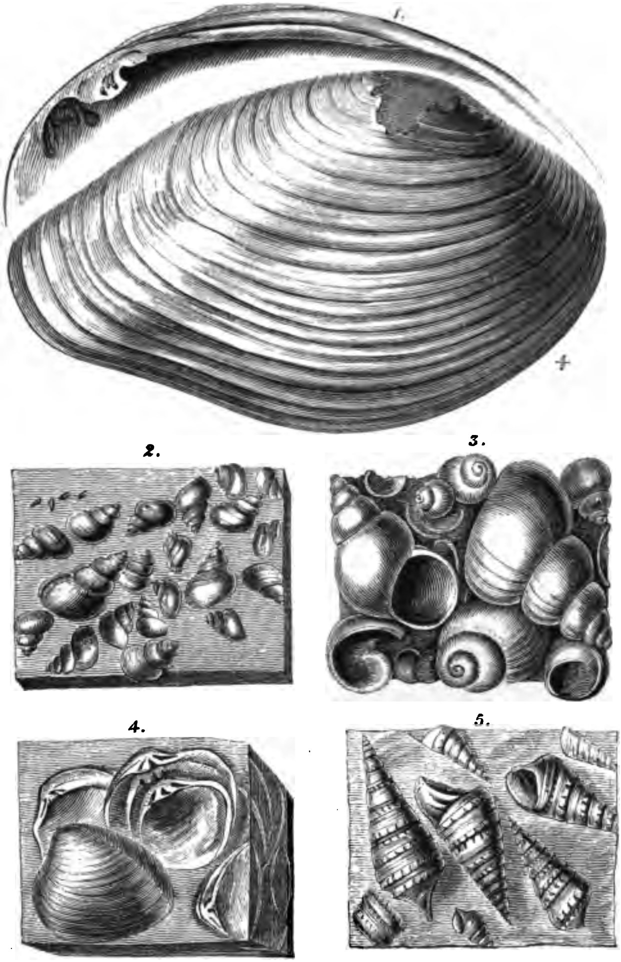
3.—*Paludina fluviorum*; a portion of a weathered slab of limestone, from Compton Bay.

4.—*Cyrena media*; in a piece of bluish-grey limestone, composed of thin bivalves; from Compton Bay.

5.—*Potamides carbonarius*; a slab of limestone formed of this species of fresh-water shell; from Compton Bay.

I have found the *Unio Valdensis* only in the cliffs, along Brook Bay; the other fresh-water shells are equally abundant in Sandown Bay. The shelly limestones of the Wealden are often used for paving in the towns and villages of the Island.

Pl. VI.



FOSSIL SHELLS FROM THE WEALDEN STRATA OF THE ISLE OF WIGHT.

GEOLOGICAL EXCURSIONS

ROUND

The Isle of Wight.

CHAPTER I.

INTRODUCTORY—GEOLOGICAL PRINCIPLES—GEOLOGY OF THE SOUTH-EAST OF ENGLAND—TABULAR ARRANGEMENT OF THE STRATA—LONDON EOCENE DEPOSITS—CHALK FORMATION—WEALDEN FORMATION—LONDON AND BRIGHTON RAILWAY SECTION—GEOLOGICAL MUTATIONS.

INTRODUCTORY.—Although this work is intended to serve as a guide for the tourist unacquainted with geology, the general diffusion of the elements of the science, which has of late years been effected by our periodical literature, renders it unnecessary to enter at large upon the principles of this department of natural knowledge. Happily the time has arrived when the grand truths relating to the physical history of the globe have, like those of astronomy, passed into acknowledged axioms; to remind the well-informed reader that the ancient sea and river beds, which constitute the dry land of the British Isles, have *not* been produced by the effects of a general deluge, would therefore be as derogatory to his understanding as to explain that the apparent revolution of the sun round our planet is an optical illusion, occasioned by the rotation of the earth on its axis.

We may, therefore, assume that every intelligent person is aware that the rocks and stones, and solid mineral masses, composing the dry land, have originally been in a softened or fluid state, either from the effects of water, or from exposure to a high temperature; that the strata are accumulations of consolidated mud, sand, and other detritus, the sedimentary deposits of rivers and seas, combined with the durable remains of animals and plants, which lived either on the land, or in the water; that *chalk* is an aggregation of shells, corals, and amorphous particles of carbonate of lime, so minute as to be undistinguishable by the naked eye, yet easily recognisable under the microscope; that the layers and nodules of flint have originated from solutions of siliceous earth in heated vapour or water, that were periodically erupted into the cretaceous ocean; that the fossils so abundant in the chalk are the relics of animals and plants that lived and died in that ancient sea, associated with the remains of a few terrestrial species; that these accumulations of organic and inorganic materials have gradually consolidated, and subsequently been elevated from the depths of the ocean by those subterranean forces that are everywhere in action, and of which the earthquake and the volcano are paroxysmal effects; and that such transmutations of the sea and the land have been, and are, constantly taking place.

GEOLOGICAL PRINCIPLES.—From the first moment that dry land appeared on the earth's surface, whatever may have been the materials of which it was composed, the disintegrating effects of atmospheric agents, and of water in motion, must have commenced. The detritus thus produced, transported to the tranquil depths of the ocean, would there subside in successive layers, and a series of sedimentary strata be gradually formed; and after the creation of living things, the durable remains of animals and vegetables must have become intermingled with the detritus of the land, and imbedded in the deposits then in progress. If the land were sterile, destitute of vegetation, and untenanted by any species of animals, the relics of the inhabitants of the sea would alone be imbedded: on the contrary, if the sediments were produced by the action of streams and rivers flowing through a country covered with forests, and swarming with animal life, the strata accumulated in lakes and inland bays would teem with the remains of terrestrial and fluviatile animals and plants.

The evidence which fossil remains afford of the changes that have taken place in the organic and inorganic kingdoms of nature, in periods antecedent to all human history and tradition, is, therefore, of the most positive and unequivocal character. If, for example, a series of strata contains exclusively relics of marine fishes, shells, corals, &c., it is obvious that it must have been formed in the sea; the state of the organic remains, and the nature of the species—whether *littoral*, *i. e.* inhabitants of shallow waters; or *pelagic*, *i. e.* species which lived in the depths of the ocean—affording indications as to the circumstances under which the formation of the strata took place. If an intermixture of land and fresh water with marine species occurs, it is evident that rivers and their tributaries brought into the sea the spoils of the land, and the relics of its inhabitants. On the other hand, if an extensive tract is composed of laminated clays, sands, and marls, teeming with terrestrial and fluviatile shells, and containing waterworn bones of land-animals, and branches, leaves, and fruits of trees and shrubs, without any intermixture of marine exuviæ, we have unquestionable evidence that these strata are either the consolidated deltas of rivers, or the sediments of lakes of an extensive continent, which was clothed with vegetation, and tenanted by terrestrial quadrupeds. As the principles involved in these deductions afford an easy interpretation of the geological phenomena of the Isle of

Wight, I would fain hope that the subject may be rendered intelligible to the general reader, who now, for the first time, enters upon an investigation of the physical structure of this interesting district.

GEOLOGY OF THE SOUTH-EAST OF ENGLAND.—Before we proceed on our excursions, it, is, however, necessary to take a comprehensive view of the Geology of the South-east of England; for as the "beautiful Island" is but a detached mass of strata, severed at some remote period from the main land, a general idea of the nature of the formations of which this part of Great Britain is composed will materially facilitate our comprehension of many local appearances, which, occurring as isolated phenomena, would otherwise be difficult of explanation, if not altogether unintelligible.

The numerous strata, or accumulations of sedimentary detritus, composing the south-eastern portion of England, are separable into four well-marked natural groups or formations.

I. THE DRIFT, or *Alluvium* and *Diluvium*.—These are the uppermost or superficial deposits, and consist of irregular layers of waterworn and drifted materials, containing the skeletons of extinct species of colossal herbivora —as the mastodon, mammoth, rhinoceros, hippopotamus, elk, deer, &c., and in certain localities of the remains of carnivora, rodents, &c., some of extinct, and others of species still existing in these islands. These beds, which rarely exhibit indications of tranquil deposition, are heterogeneous layers of debris, which have either been transported by the sea, or by river currents, or by floating ice, or driven by waves of translation occasioned by elevations of the bed of the ocean, into estuaries, bays, and creeks.

II. TERTIARY EOCENE* FORMATION OF THE LONDON

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* *Eocene*, a term applied by Mr. Lyell to the earliest tertiary formations. See "Medals of Creation," vol. i.

BASIN.—This series is chiefly composed of layers of stiff, dark bluish-grey clay, abounding in marine shells, and having strata of sand and gravel in the upper part, and sand, gravel, and mottled clays in the lower part, with freshwater shells and plants in some localities; the total thickness amounts to several hundred feet. The fossils are almost entirely of extinct species.

III. THE CHALK FORMATION.—The white calcareous rock called *chalk* is well known; but in the nomenclature of geology, the term *chalk formation* comprises not only the limestone that extends over so large an area in the south-east of England, but also numerous beds of sand, sandstone, clay, and limestone, that are very dissimilar in their appearance and chemical characters, yet so far correspond in the nature of their organic remains, as to show that the entire group was formed during the same geological epoch. In other words, that the sea and land, and their inhabitants, underwent no essential change during the period in which the entire series was deposited: it therefore constitutes, in geological language, but one formation.

The organic remains of the chalk are essentially marine; but in some localities drifted wood and plants, waterworn bones and teeth of terrestrial reptiles, and other spoils of the land, are found associated with the shells, corals, and fishes of the cretaceous ocean; and these have evidently been transported by rivers and streams into the bed of the sea. The fossils are, with but very few exceptions, of extinct species and genera, and dissimilar to those of the tertiary strata.

IV. THE WEALDEN FORMATION.—This is an extensive series of clays, sands, sandstones, and shelly limestones, upwards of 1,000 feet in thickness, characterised by the entire absence of marine fossils, and the abundance of river and lacustrine fishes, crustaceans, and shells, intermingled with bones of enormous land-reptiles, and terrestrial plants and trees, the whole group having evidently been a vast delta.

The essential characters of these formations, and of the subdivisions into which they are separated, are concisely expressed in the annexed table.

T OF ENGLAND.

	Distribution in the Isle of Wight.
cies of large	Fissures in the tertiary and cretaceous strata; the subsoil in some localities.
ish; marine	
redominate. les. Marine onkeys and ds, serpents, a; nautili; , and fruits.	The northern parts of the island. The freshwater beds prevail along the northern shore, from Headon Hill to White-cliff Bay; the marine from Alum Bay, along the northern flanks of the chalk hills, to White-cliff Bay.
tili, belem- hinoderms; and turtles. Fuci; drift- genera and entially dif- s. hite chalk, Ammonites, ; siphoniæ, tes. Some ns of *mol-* y peculiar yer of shell ristic shells, wood with this division eans; bones wood, and	The Downs from Culver Cliff to the Needles; and from St. Catherine's to Shanklin Down. The Undercliff and the southern coast are formed by the lower subdivisions of the chalk, except in the two following localities.
throughout nsive beds, freshwater *les*). Bones estrial rep- rtles, both ferous trees ena, Yucca, Ferns of	Sandown Bay, between the Greensand of Red-cliff and Shanklin Chine. Brook Bay and along the coast, between the Greensand of Compton Bay and of Atherfield Point.

ORDER OF SUPERPOSITION.—Such is the chronological sequence of the formations of the south-east of England; in other words, these several groups of marine and fresh-water sediments have been deposited in the following order:—

1st, The *Wealden:* the delta of a river, composed of the spoils of a vast continent, of which no other vestiges remain. These strata rest upon a marine formation called the *Oolite,* but which does not come within the scope of our present observations.

2ndly, The *Chalk:* the bed of an ocean of great extent, deposited upon the Wealden.

3dly, *The Tertiary Eocene Formation:* accumulated in depressions or basins on the surface of the Chalk.*

Now, as each of these formations is many hundred feet in thickness, it follows that the inferior strata would for ever have been concealed from observation, had the original order of superposition remained undisturbed. But not only portions of each of the upper series appear on the surface, but even the lowermost deposits form an extensive tract of country which is diversified by hills and valleys, and constitutes one of the richest agricultural provinces of the British Isles. This distribution of the strata has originated from the displacements occasioned by those disturbing forces which elevated above the waters the ancient ocean and river beds, and converted them into dry land. The nature of those changes we now proceed to consider.

LONDON EOCINE FORMATION.—The London Tertiary or Eocene deposits form the area on which the metropolis is situated, as well as the surrounding country to a distance varying from ten to twenty or thirty miles. Around these strata the Chalk presents a distinct boundary of hills on the south, west, and north; but on the east the range is broken, and though this chasm the Thames winds its way to the sea.

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* With the view of simplifying the subject, the *Drift,* or superficial alluvial deposits, will not be especially alluded to in these excursions.

From this geological character of the metropolitan district it results, that all the lines of railway that proceed from London traverse, for the first ten or twenty miles, beds of clay, loam, and loosely aggregated sand and gravel; hence the numerous slips that have taken place in the embankments at New Cross, Wandsworth, Hanwell, &c.; and in all these lines it is obvious, from the nature of the soil and the steepness of the cuttings, that similar subsidences will again occur.

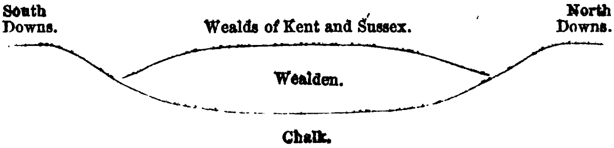
CHALK FORMATION.—The next geological feature observable along the London railways is the *Chalk*, which is invariably traversed by steep cuttings and tunnels; as, for example, in the South-eastern line, from Croydon to Merstham; and in the Great Western, from Maidenhead to beyond Wallingford. After passing through the chalk, the lower subdivisions of the cretaceous formation, viz., the *Marl*, *Firestone*, *Galt*, and *Greensand*, successively appear; and these are followed by the *Oolite* on the Great Western and Birmingham lines, and by the *Wealden* on the South-Eastern; but on the South-Western, by which we shall travel to Southampton, the chalk and the tertiary strata only are exposed.

The chalk, as is well known, constitutes the prevalent geological feature of this part of England. The upper or white chalk rises into chains of hills, called downs, which are remarkable for their smooth and undulated outline, and form a well-defined geographical boundary. The southern range extends from Hampshire, through Sussex to the sea-coast, terminating in the bold promontory of Beechy Head; the northern passes from Hampshire through Surrey and Kent to the British Channel, and ends in the line of cliffs near Dover.

The lower cretaceous strata compose ranges of hills less uniform in elevation and extent, which skirt the inner margin and escarpments of the Downs, and in some parts of Surrey and Western Sussex attain an altitude equal to that of any portion of the North or South Downs. Leith Hill, in Surrey, is nearly 1,000 feet above the level of the sea.*

WEALDEN FORMATION.—The Wealden deposits fill up the whole of the area between the North and South Downs, and are bounded on the west by the cretaceous strata of Hampshire, and on the east by the British Channel. They form the sea-coast from Pevensey in Sussex to Hythe in Kent.

Looking down upon the Wealden from any of the heights that command a view across the district, and of the distant boundary of chalk downs—as, for example, from Leith Hill, or from the summit of the escarpment of the North Downs, near Reigate†—the observer might suppose that these freshwater sediments occupy a depression or basin on the surface of the chalk, and that the strata of the North and South Downs extend under the whole of the deposits in the intervening area, as in the following diagram:—



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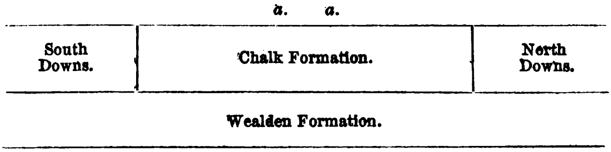
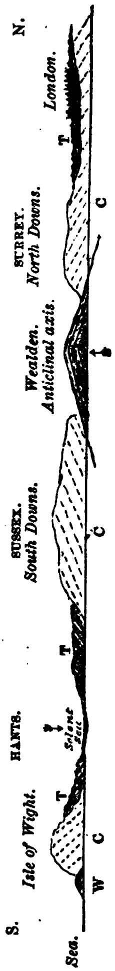
* For details, *vide* a "Memoir on the Geological Structure of the Country seen from Leith Hill," in the County History of Surrey, published by Mr. Ede of Dorking.

† See "Wonders of Geology," vol. i. p. 342.

Several writers on geology have fallen into this error, and indulged in the most absurd speculations accordingly. A slight examination of the relative position of the respective strata where in contact is, however, sufficient to show the incorrectness of this hypothesis, and to prove that the Wealden extends under the chalk, both on the north and south, as shown in the subjoined plan, and in lignographs 2, 3. It is therefore certain that the cretaceous formation was deposited upon the Wealden; and it is equally clear that it originally extended not only over the entire district between the North and South Downs, and was connected on the west with that of Hampshire and Wiltshire, but also that it filled up the space now occupied by the British Channel, and was united with the chalk of the Isle of Wight and of the Continent.



If we assume the original position of these ancient fluviatile and marine formations to have been as represented in the above diagram, and suppose that the middle portion of the chalk *a a* were removed, so as to expose the underlying Wealden, we should have chalk downs on the south and north, with an intervening area of the inferior beds denuded or laid bare by the removal of the superincumbent strata. Such, in fact, would have been the actual state of the south-east of England, if the changes here contemplated had been produced by the wearing away of the chalk from the underlying fluviatile sediments, and the horizontality of the strata had been maintained. But a careful examination of the phenomena under review shows



T. Tertiary. C. Chalk. W. Wealden.

LIGN. 1.—SECTION FROM LONDON TO THE SOUTHERN COAST OF THE ISLE OF WIGHT.

that the removal of the chalk was not affected by simple denudation, but by a force acting from beneath, which elevated the entire series of tertiary, cretaceous, and wealden formations in a line bearing a general direction from east to west; by which movement an anticlinal* position has been given to the strata on each side the axis of greatest elevation. This axis is denoted in the physical geography of the district by the chain of hills called the Forest-range, that extends from the sea-coast at Hastings through the interior of the country by Crowborough, the highest elevation, to Loxwood, west of Horsham, where the Wealden disappears beneath the overlying greensand strata. In all transverse sections of the district, *i.e.* from north to south—whether on the coast, or inland—the strata on the north of the central line dip northward, or rather to the north-east, and those on the south to the south-west. There are, of course, many local variations in the inclination of the rocks, and numerous lesser anticlinal axes, or *saddles*, as they are provincially termed, and also longitudinal ridges and corresponding valleys running parallel with the principal line of the disturbing force.

In consequence of this displacement of the strata, a section drawn from London through the North Downs, across the Wealden district, through the South Downs, and carried on to the southern coast of the Isle of Wight, would present the arrangement shown in lign. 1.

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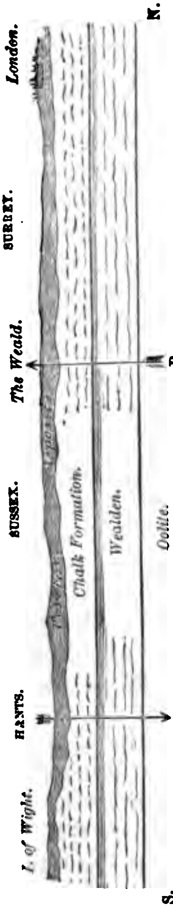
* *Anticlinal*—Inclined towards each other, like the ridge-tiles of the roof of a house.

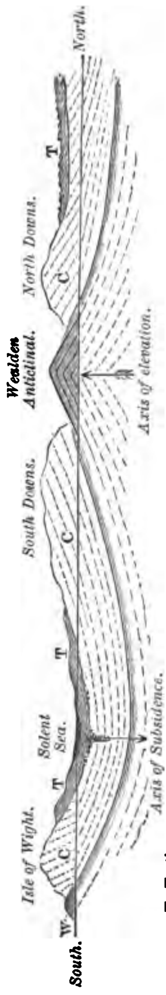
In this lignograph are represented the *tertiary* of the London basin resting on the chalk; the *chalk* of the *North* Downs, dipping northwards; the anticlinal position of the *Wealden;* the *chalk* of the *South* Downs, dipping southwards, with *tertiary* strata on the southern flank: then the depression which forms the channel of the Solent sea; the *tertiary* strata extending over the northern portion of the Isle of Wight; the *chalk* downs of the Island, dipping northward; and lastly, a small portion of *Wealden,* emerging from beneath the chalk, on the south coast, at Brook and Sandown bays.

LONDON AND BRIGHTON RAILWAY SECTION.—A portion of this section is well displayed along the line of railway from London to Brighton. Leaving the station at London Bridge, the tertiary clays, with their characteristic fossils, are seen from beyond Deptford, by New Cross, Sydenham, &c.; and approaching Croydon, beds of gravel appear, with interspersions of olive-green sand. The valley beyond Croydon, along the side of which the railway proceeds, is a thick bed of gravel resting on the chalk. Beyond the station called Stoats'-nest, is a fine section of the chalk with flint, and the North Downs are traversed by a long tunnel carried through the solid chalk, and emerging near Merstham, where the firestone and marl rise to the surface. The sands and clays of the chalk are passed at the Red-hill and Godstone stations, and the Wealden clays appear; and at Horley are succeeded by shales, limestones, sands, and sandstones, to the Crawley station. Passing through a long tunnel in the Wealden, we arrive at Balcombe, where laminated sandstone and shale are seen on each side the cutting. The general dip of the strata hitherto passed is to the *north-east;* but after crossing the deep Wealden valley beyond Balcombe, over a magnificent viaduct, the line runs along alternating layers of sands and clays, which dip to the ***south-west;*** we have therefore arrived on the southern side of the grand anticlinal axis of the Forest ridge. The Wealden strata continue with the same general inclination by Hayward's Heath, which is traversed by a tunnel, to beyond St. John's Common, where they disappear beneath the lowermost greensand beds of the chalk formation. The galt, firestone, and marl succeed, and lastly, the white chalk of the South Downs, at Clayton Hill; through the base of which a long tunnel is carried, and emerges on the Downs on the south. The remainder of the line to the Brighton station runs over, or through, hills and valleys of the white chalk. Thus this railway passes through two ranges of chalk hills, viz. the North and South Downs, by tunnels; two of greensand, viz. near Red Hill, in Surrey, and Hurstperpoint, in Sussex; and two principal ridges of Wealden, viz. at Balcombe, and Hayward's Heath.



LIGN. 2.—DIAGRAM OF THE ORIGINAL POSITION OF THE TERTIARY, CHALK, AND WEALDEN FORMATIONS.

Geological Mutations.—The present distribution of the strata, as shown by the preceding observations, appears to admit of the following explanation. Assuming the original



W. Wealden. C. Chalk. T. Tertiary.

LIGN. 3.—IDEAL SECTION FROM LONDON TO THE SOUTHERN COAST OF THE ISLE OF WIGHT.

deposition of the strata to have taken place as in lign. 2—the Wealden resting on the oolite, the chalk on the Wealden, and the tertiary on the chalk—the surface of the country must have consisted of the same strata as those of the immediate vicinity of London. Now, if any elevatory force acted from beneath, in the direction of the arrow, B, the entire series would be broken through, and the chalk, with the tertiary it supported, thrown into highly inclined positions to the north and south; and if a similar disturbance took place along the area now occupied by the British Channel, England would be separated from the continent, and the small portion, now the Isle of Wight, forced into its present position, by a subsidence taking place in the direction of the arrow, A, along the present bed of the Solent Sea. The actual position of the strata, could our observations extend to a sufficient depth, would probably present the section sketched in lign. 3; which is in accordance with the local phenomena that will come under review in our geological excursions round the Isle of Wight. It is obvious that if the Forest range of the county of Sussex were swept away by the encroachments of the sea, and the area it occupied buried beneath the waves, the North Downs would present a strict analogy in geological structure to the Isle of Wight; for a portion of the Wealden would appear on the south shore at the base of the chalk escarpment, and be succeeded on the north by the greensand, galt, firestone, marl, and white chalk; and the latter would be covered by tertiary eocene deposits.*

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* For detailed information on the geology of the South-east of England, and of the subjects embraced in this concise sketch, see "Elements of Geology," by Mr. Lyell, and the "Geology of the South-east of England," and the "Wonders of Geology," by the Author. On the elevation of the Wealden and the consequent changes in the relative level of the sea and land, the masterly paper of Mr. Hopkins, "On the Geological Structure of the Wealden District and of the Bas Boulonnais" (Geol. Trans. vol. vii.), should be consulted.

CHAPTER II.

SOUTH-WESTERN RAILWAY—STRATA OF THE LONDON BASIN—ARTESIAN WELLS—RAILWAY SECTIONS—SOUTHAMPTON STATION—FROM SOUTHAMPTON TO THE ISLE OF WIGHT—GEOLOGICAL STRUCTURE OF THE ISLAND—RIVERS AND STREAMS—FROM COWES TO RYDE.

South-western Railway.—The railway from London to Southampton and Gosport lies so far to the west of the Wealden denudation of the south-east of England, which is traversed by the Brighton line (see p. 50), that all the deposits below the upper chalk are concealed from view, and inconsiderable cuttings through tertiary strata, and chalk, are alone exposed.

The metropolitan station at Vauxhall, on the southern bank of the Thames, is situated on the alluvial silt and loam, which are spread over areas formerly covered by the waters of the river, and now constitute the subsoil of the meadows and lowlands that skirt its banks; these beds contain shells of recent species of fluviatile mollusca. On penetrating the soil, gravel, loam, and sand are met with in which are found bones and teeth of several kinds of large mammalia belonging to extinct species of elephant, rhinoceros, horse, buffalo, elk, deer, &c.; an assemblage of organic remains common in similar deposits in other parts of England and on the Continent.*

In the county of Surrey the subsoil of the district traversed by this railway in many parts consists of thick beds of gravel, in which fossil bones and teeth of elephants, horse, and deer, have been discovered; but remains of this kind are more abundant in the loam and clay. The gravel is almost entirely formed of broken chalk-flints, worn by the action of water into boulders, pebbles, and sand. It abounds in siliceous fossils of the chalk, and an interesting series of the sponges, zoophytes, and echini of that formation may be collected from the pits around the metropolis.*

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* See "Wonders of Geology," fifth edition, vol. i. p. 145.

STRATA OF THE LONDON BASIN.—The tertiary or eocene strata of the London basin which lie beneath the accumulations of drifted materials above described, and fill up a depression of the chalk (see lign. 1, p. 49), are divided into three groups; viz. 1, *Bagshot sands;* 2, *London clay;* 3, *Plastic clay.* The uppermost † consists of beds of sand and sandstone, with intercalations of marl and clay. These strata cover the London clay from near Finchley on the north to Hampstead-heath, and form part of the eminence on which Highgate is situated. The Bagshot sands appear at Egham, and extend, with some interruptions, to near Guildford; and from the vicinity of Kingston to seven miles west of Bagshot, spreading over part of Windsor forest. Several eminences in Surrey are capped by this sand; at Tucksbury-hill, north of Farnham, it occurs at an elevation of 500 feet.‡ From the siliceous nature of the soil formed by these deposits, the districts in which they occur are exceedingly sterile, supporting only a covering of heath and furze; hence the numerous uncultivated wastes within a short distance of London. But where the clays rise to the surface, verdant spots appear in the midst of these desolate tracts. The situation of these argillaceous beds is indicated by the oozing of water, and the growth of rushes in the bottoms of the shallow valleys that traverse the sandy plains, and which are often covered with peat. Some of the Bagshot sandstone is remarkable for its structure, which partakes more of the character of a peculiar crystallization than of a mere aggregation of siliceous particles; a mass of the white variety recently broken strikingly resembles the surface of lump sugar. Erratic blocks of this sandstone are common on the chalk downs of Wilts, Sussex, Kent, &c., and are provincially called the Grey Wethers; they occur also in the superficial drift and gravel.

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* The flints of the gravel often enclose beautiful examples of the microscopic fossils which abound in many of the siliceous nodules of the chalk: some of the most interesting specimens of fossil animalcules in my cabinet were obtained from the gravel on Clapham and Wandsworth commons.

† Bagshot sands; so called from the district over which they are most widely expanded.

‡ Brayley's History of the County of Surrey, vol i. p. 131.

LONDON CLAY.—This deposit in the neighbourhood of the metropolis forms a dark-blue stiff soil, and has occasional intermixtures of green and ferruginous sands and variegated clays. It abounds in spheroidal nodules of indurated argillaceous limestone termed *septaria*,* which are internally traversed by veins of spar disposed in a radiated manner from the centre towards the circumference, and often contain shells and other organic remains.† The septaria are generally distributed in horizontal layers, and lie at unequal distances from each other. Brilliant pyrites and crystals of sulphate of lime abound in the clay.

Plastic Clay.—Beneath the extensive and thick deposits of London clay, and interposed between them and the chalk, there occur in some localities strata of sand of various colours, alternating with layers of bluish plastic clay; and there is very constantly in the lower part of the series a bed of green sand, which abounds in oyster shells and pebbles, and in some localities (as near Bromley) passes into a hard rock or shelly conglomerate. Lignite, leaves of land-plants, and freshwater shells are contained in some of these layers; but in many places there are no remains of this kind found in the eocene beds immediately above the chalk; and the term *plastic clay,* as indicating a particular group, can only be regarded as of limited application.*

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* The septaria, when calcined and ground, constitute the composition called Roman cement.

† "Medals of Creation," p. 373.

ARTESIAN WELLS.—From the alternation of porous sandy strata with stiff impervious clays throughout the London basin, the district around the metropolis is favourable for obtaining water, by means of the borings, termed *Artesian wells,* by which perennial fountains are raised from the natural reservoir of water in the lowermost arenaceous deposits. The nature of these springs is easily explained. The beds of sand under the clay are fed by the rain that falls on the uncovered margin of the basin, and the water percolating through the porous strata, gradually accumulates till a reservoir is formed beneath the central plateau of clay. If this stratum be penetrated, the water must necessarily rise to the level of the fluid in the highest part of the subterranean lake, and may therefore flow to the surface, or even escape in jets to a considerable height above it. Such is the phenomenon of the Artesian wells in and near London. The impermeable clay confines the water contained in the sand beneath; the engineer perforates this bed with his borer, and introduces tubes for the passage of the pure element to the surface, and the exclusion of the brackish water that may ooze from the saliferous strata above; for although the wells sunk into the London clay yield no water, the sands alternating with the argillaceous beds afford a limited quantity. The prevalence of various saline minerals, however, in the clay, such as the sulphates of iron, lime, and magnesia, generally renders the water derived from this source unfit for domestic purposes; and the borings are carried down to the sands of the plastic clay before a copious supply of excellent water can be obtained.* The total thickness of the London clay, in some situations, is estimated at nearly 1,000 feet; the wells on the Surrey side of the Thames are from 100 to 600 feet deep.

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* The term plastic clay (*argille plastique*) was given to this lowermost division of the eocene strata in conformity with the nomenclature of the French geologists; but the beds thus named are less developed in the London than in the Paris basin, and do not with us possess distinctive characters sufficiently important to warrant their separation from the other intercalated fresh water deposits of this formation.

The Railway Sections.—The above preliminary remarks will enable the observer to understand the nature of the strata of which transient glimpses may be obtained on each side the railway in the rapid transit from London to Southampton, on which we now proceed without further comment. Although no considerable sections of the eocene strata are traversed by this line, yet here and there the characteristic soil of the London clay may be seen in the cuttings, where the surface has not acquired a covering of turf. On Wandsworth Common the banks on each side are composed of this clay, with a superficial capping of gravel and sand. When the railway was in progress numerous fossils were dug up; and even now the slips of the embankments which occasionally take place expose specimens of nautili and other shells, petrified wood, &c.*

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* The most remarkable instance of success in obtaining a perennial fountain from a deep source by the process of boring described in the text, is that of Grenelle, near Paris. An Artesian well is there carried to the extraordinary depth of 1,800 feet, passing through the entire thickness of the eocene strata of the Paris basin, and the underlying chalk, firestone, and galt, to the greensand. The water rises in a powerful column to the height of 30 feet above the highest part of Paris, and has a temperature of 91 degrees Fahrenheit! being sufficiently warm for the heating of green-houses, &c.

At Esher, the clayey district of the Bagshot sands prevails, and overlies the London clay, which in our further progress is generally concealed by the sands of this subdivision of the eocene strata. At Goldsworth-hill, four miles north of Guildford, a deep section of the Bagshot sands is exposed, consisting of greenish and yellowish sands, in which fossil teeth and other remains of several kinds of fishes (principally of the *Shark* family), and casts of shells, have been discovered. The most interesting fossil obtained is a large tooth of a *Saw-fish*, which, at that time, was the only known instance of the genus *Pristis* in the English strata; but, subsequently, examples of the teeth have been found in the clay of Bracklesham, in Sussex. The other teeth are referable to three kinds of cartilaginous fishes, and with them were associated teeth and palatal bones of *Rays*, and vertebræ of osseous fishes, of species common in the clay of Sheppey; also a portion of the carapace or buckler of a freshwater turtle.†

At Weybridge the banks show an example of false stratification, as it is termed, of white and fawn-coloured sands, with the usual capping of gravel and clay. At Woking Common the Bagshot sands still prevail, their sterile surface being covered with heather and broom, except in a few places, where interspersions of clay produce verdant spots, which appear like oases in the desert. Greenish clays and marls, alternating with sand, are next seen, and extensive plains clothed with heather, and dotted with clumps of pines and firs. Between Woking and Farnborough many sections of the Bagshot sands are passed, and at the Wingfield station the country presents the same geological character. Although from the rapidity of our progress but transient glimpses can be obtained of the adjacent district, yet the character of the vegetation, and the appearance of the unenclosed tracts, destitute of all traces of habitation, save a few solitary turf cabins, convey some idea of the nature of the untractable soil produced by these siliceous deposits. Such, indeed, is the general aspect of sterility in the worst parts of the Bagshot heaths that, when the adjacent fertile region is hidden from view, a stranger might suppose himself transported to a desolate mountain moor in the border countries.*

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* See "Geological Survey of Surrey," in Brayley's History of the County, vol. i. pl. 1, 2, in which several of the fossils discovered in the clay of Wandsworth Common are figured.

† Notice of Fossils discovered in the Bagshot Sand at Goldsworth-hill, Surrey, by the Rev. Dr. Buckland. Proceedings of the Geological Society of London, vol. ii. p. 687.

About three miles before we reach the station at Basingstoke,† the *Chalk* emerges, and is seen covered with a bed of tertiary sand; and at Andover-road station the railway cutting exposes a good section of the upper-chalk, which now continues, in greater or less thickness, surmounted in some places by patches of tertiary clays and in others by gravel and loam, till we approach Southampton, where it is wholly concealed by the alluvial and eocene deposits. At the Winchester station, which is on the chalk of the Hampshire downs, we have a fine view of the river valley, in which stands the venerable city of the immortal ALFRED, hallowed by so many glorious associations of the olden time; and we catch a glimpse of that precious monument of antiquity, the Hospital of Saint Cross, with occasional views of the crystal streams of the river Itchin, as they pursue their tortuous course through the verdant chalk-valley to Southampton-water.

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* Mr. Warburton on the Bagshot Sands, Geol. Trans. vol. i. p. 49.

† The picturesque ruins of the Chapel of the Holy Ghost, said to have been erected *temp.* Edward IV., on the right of the station at Basingstoke, are worthy the notice of the traveller. An elegant hexagonal turret tower at the south-west, and part of the east and south walls, are visible from the railway.

SOUTHAMPTON STATION.—The accumulations of alluvial gravel and loam around Southampton are in many places of considerable thickness. The organic remains hitherto discovered in these beds are but few; comprising only some detached bones, and a tooth of a mammoth, and bones of a species of horse and deer; and as the tertiary strata are in a great measure obscured by the superficial deposits, there are no productive localities of fossils in the immediate vicinity of Southampton. The nature of the strata to a considerable depth has been ascertained by the borings lately undertaken to obtain a more ample supply of water for the inhabitants than that yielded by the numerous private wells in the town. These are sunk through the bed of gravel which overlies the London clay, to a depth of from 10 to 25 feet, this clay forming the water shed or natural tank of the surrounding district. At the railway station an Artesian well, which overflows from a depth of 220 feet at the rate of ten gallons per minute, was formed by boring till the beds of sand of the plastic clay, which lie between the London clay and the chalk, were reached; the water in this well rises, therefore, from the same geological source as the springs near London.

A few years since it was resolved to obtain a more copious and constant supply for the town, by sinking an Artesian well on the Common. The operations were commenced in 1838, and have now reached a depth of 1,260 feet, at an expense of 24,000*l.* The following is the section made by the borings:—

Drift, or alluvial soil . . .	38 feet,
London Clay	304* —
Plastic sands and clays . . .	97 —
Chalk	821 —

This well yields by pumping 15,000 cubic feet of water daily, but the quantity is only one-half of that required; and it will be necessary to continue the borings till the firestone is reached (probably a further depth of from 150 to 200 feet) before an adequate flow of water is likely to be obtained.† The impervious blue chalk-marl or *galt*, which underlies the firestone, generally supports an abundant sheet of water; but whether a stream will rise to the surface is extremely uncertain, and depends on the level from which the water is derived that feeds this subterranean reservoir, and the condition of the basin which sustains it.‡

The branch of the South-western railway that extends to Gosport cuts through a few ridges of tertiary clays, sands, and gravel, capped with drift; but these present no sections of particular interest.§ At Stubbington, between four and five miles west of Gosport, near which the line passes, many interesting fossils have been obtained from the tertiary clays and sands.*

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* Many of the characteristic shells of these strata were brought up by the borer.

† See an admirable Address on this subject to the Mayor of Southampton and the Members of the Artesian Well Committee, by the Very Rev. Dr. Buckland; July, 1845. At the late meeting of the British Association of Science at Southampton, the president, Sir Roderick Murchison, and several other eminent geologists, examined the borings, and recommended the continuance of the operations till the firestone was reached.

‡ In the chalk districts of the South-east of Sussex copious streams of the purest water rise from the junction of the grey marl with the white chalk.

§ Portsmouth and Gosport are built on eocene strata; the wells penetrate the London clay to the depth of from 200 to 300 feet.

SOUTHAMPTON TO RYDE.—The steamers from Southampton to the Isle of Wight generally touch at East Cowes, and proceed to Ryde; those from Portsmouth cross Spithead to the latter town, the distance being scarcely five miles. In the former route we pass down Southampton-water, an arm of the sea which extends ten miles inland in a north-westerly direction, and separates the eastern part of the coast of Hampshire from the New Forest on the west. The entrance of Southampton-water is guarded on the west by Calshot Castle, which was erected by Henry VIII. on the narrow slip of land that here advances some little distance from the line of coast. We now obtain a distinct view of the north side of the "beautiful Island;" and as we approach the land two parallel chains of hills may be observed, stretching in a direction east and west through the whole extent of the landscape. The nearest range is of moderate height, and slopes towards the shore; the distant chain, which bounds the horizon on the south, rises with a bolder sweep and to a much greater elevation, and exhibits the smooth and rounded aspect and undulated outline, which are so characteristic of the mountain masses of the white chalk as to indicate their geological character, even when seen from a considerable distance. The first line of hills consists of freshwater strata, which are superimposed on the eocene marine deposits; the distant range is part of the chain of chalk downs that traverses the island throughout its entire length, forming on the east the promontory of Culver-cliff, and on the west that of the Needles. (See the map, Pl. XX.)

GEOLOGICAL STRUCTURE OF THE ISLE OF WIGHT.—

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* Several species of shells, collected by Mr. Holloway, of Portsmouth, are figured in "Sowerby's Mineral Conchology."

Before we land, and proceed to examine particular localities, it will be necessary to take a general view of the distribution of the three formations of which the island consists. It is shown in lign. 3, (p. 52), that the Solent and Spithead occupy a trough or channel from two to seven miles wide, formed by the London clay and other tertiary deposits which lie upon the chalk. The wells at Southampton, Portsmouth, &c., prove, in the absence of natural sections, that although the strata have undergone great disturbances, the same order of superposition is maintained, as in the south-east of England; and in the southern division of the Isle of Wight, where not only the lowermost cretaceous strata, but even the Wealden, rise to the surface, in consequence of the highly inclined position into which the central mass of rocks has been thrown, the natural order of the deposits is not inverted.*

The Isle of Wight is of an irregular rhomboidal form, being in length, from east to west, twenty-three miles, and from north to south, in the widest part, thirteen miles; the circumference is between seventy and eighty miles. Its surface comprises about 105,000 acres, of which 75,000 acres are under tillage, 20,000 acres are pasturage, and 10,000 acres unproductive heaths and commons. The population is estimated at nearly 45,000.

The map, Pl. XX., shows the range and extent of the respective formations which lie beneath the vegetable soil and superficial loam and gravel. The section in the same plate represents a vertical cut through the island, from Cowes on the north, to the sea-shore beyond St. Catherine's down on the south, and exhibits the relative position and direction of the principal deposits. These are further exemplified by the instructive diagram, Pl. VII., p. 67.

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* The Undercliff presents an apparent exception, for in some instances masses of white chalk are seen covered with beds of firestone, marl, and galt; but these are merely portions of the cliffs that have fallen down in a retroverted position from the encroachments of the sea in comparatively very modern periods.

By a reference to the map it will be seen that the eocene strata which were deposited on the chalk when the latter was in a horizontal position (lign. 2, p. 51), form the northern division of the island. This tract of country is coloured *pink*.

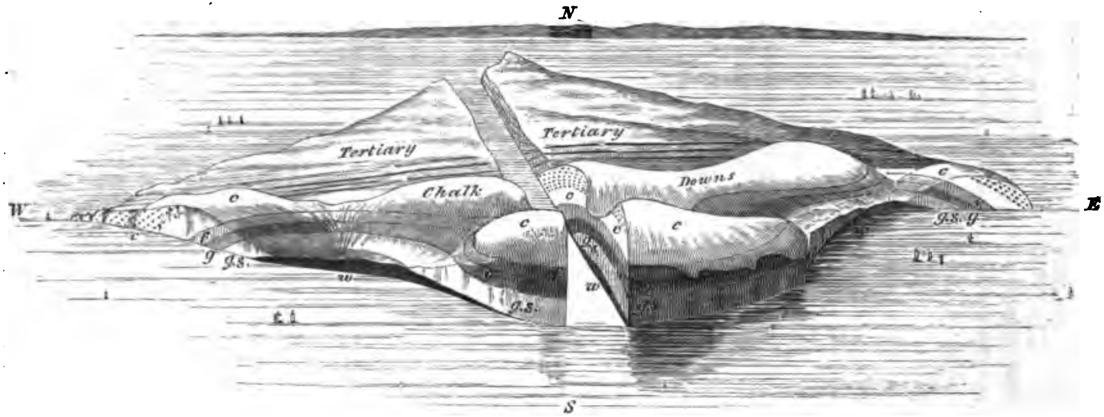
The other portion (coloured *blue*) is almost entirely composed of the different members of the cretaceous system. The white-chalk forms a range of downs from the eastern to the western extremity, and is flanked on the south by the lower beds of this formation. These are succeeded by another group of chalk-hills, that expands into a broad and lofty promontory, in some parts between 800 and 900 feet high, crested by St. Catherine's, Boniface, and Shanklin downs. On the southern escarpment of this chain the inferior deposits of the cretaceous system reappear, and fallen masses of these rocks form the irregular line of terraces which constitute the Undercliff. The downs on the southern coast are separated from those inland by an anticlinal axis which extends through this part of the island, and is produced by the upheaval of the firestone, galt, and greensand. This is shown by the section from north to south, given in the map (Pl. XX.), in which the different members of the chalk formation are defined by variations in the lines of shading, as explained in the index of colours.

The promontory of the Undercliff is flanked both on the east and west by extensive bays, which have been excavated in the clays and sands of the Wealden and inferior cretaceous deposits, by the long-continued encroachments of the sea. The Wealden (coloured *sienna* on the map) occupies an inconsiderable extent of surface; but in Sandown Bay on the east, and in Brixton, Brook, and Compton bays on the west, the cliffs, which are formed of the upper clays and sands of this formation, are exposed to unremitting destruction from the action of the waves. The sea-shore is therefore strewn with the detritus of these fluviatile strata, and the shingle contains innumerable water-worn fragments of the bones of reptiles, and other organic remains.

That the general reader may obtain an accurate idea of the phenomena above described, the diagram, Pl. VII., for which I am indebted to my friend Professor John Phillips, is subjoined. In this plan the geographical features of the island are intentionally exaggerated, that the most important physical characters may be clearly understood. The northern district, consisting of fresh-water and marine eocene deposits, is marked *tertiary*. The chalk downs are seen in their full extent from east to west, the dotted lines denoting the inclined direction of the strata as indicated by the layers of flint nodules; and the lower members of the cretaceous system occupy the southern portion of the island, the principal subdivisions—viz., the *firestone* (*f.*), *galt* (*g.*), and *greensand* (*g.s.*), being marked with letters of reference. The *Wealden* strata (*w.*) are shown in the bays on the east and west of the Undercliff. The vertical cut or section through the Island from north to south explains the position and flexures of the strata, which have given rise to the present geological characters of the surface of the country, the Wealden constituting the foundation and central axis of the island.

RIVERS AND STREAMS.—There is a good supply of water, at a moderate depth, throughout the greater part of the less elevated districts; but the rivers and streams are neither numerous nor considerable. The drainage of the country is chiefly effected by four or five rivers that flow from the northern flanks of the chalk downs. Of these the principal is the Medina, which, rising at the north-eastern base of St. Catherine's Hill, meanders along

Pl. VII.



A DIAGRAM ILLUSTRATIVE OF THE GEOLOGICAL STRUCTURE OF THE ISLE OF WIGHT.

By John Phillips, Esq., F.R.S., &c.

c. Upper and lower Chalk, f. Firestone. g. Galt. g. s. Greensand. w. Wealden.

the valley that runs to the east of Gatcombe and Mountjoy. The river flows on to the east of the town of Newport, and soon expands into a wide estuary, which opens into the sea on the north; the towns of East and West Cowes being situated on the banks of the embouchure of the river.

Between Ryde and Cowes there is an estuary fed by springs that issue from the northern foot of Arreton and Ashey downs, and form a considerable breadth of water at Wooton Bridge, called Wooton River. The estuary below the bridge communicates with the sea, and is termed Fishbourne Creek.

The most considerable estuary of the island is Brading Haven, which covers 800 acres, and at high water has the aspect of a beautiful lake; but during low water it is a muddy swamp, through which meanders an inconsiderable river called the Eastern Yar, originating in springs that rise at the foot of the chalk range near Godshill.

Newtown Bay, between Cowes and Yarmouth, is the mouth of a small river of the same name, which is mainly fed by a copious stream that rises near Calbourne.

The Western Yar has its source from springs that burst forth from the foot of the chalk near Freshwater, within a short distance of the southern shore, and quickly expands into an estuary that falls into the sea at Yarmouth, the entire length of the river scarcely exceeding three miles.

Along the southern shore of the Island there are no streams sufficiently large to deserve the name of rivers; but the clay beds that, in some parts of the cliffs, are covered by porous strata many yards in thickness, give rise to copious rivulets, some of which issue from a great height, and, dashing from ledge to ledge, fall into the sea in cascades of considerable picturesque beauty. Those of Shanklin and Blackgang Chines (Pl. XIII.) are well-known examples.

From Cowes to Ryde.—From the highly-cultivated state of that portion of the Island we are approaching, and the luxuriant woods and copses with which it is adorned, its geological construction is almost wholly concealed from view. The water-worn blocks of limestone on the sea-shore, and the layers of tertiary strata exposed in those places where recent encroachments of the sea have undermined the low cliffs which skirt the plantations along the water's edge, afford, however, indications of the nature of the deposits composing this district. As there are no localities of geological interest around Cowes that are accessible to strangers, we proceed to Ryde, the quarries at Binstead, in the vicinity of that town, exhibiting good sections of the fresh-water strata, which extend through the Island from Headonhill on the west, to St. Helen's and Bembridge on the east. On landing at Ryde pier, if at the recession of the tide, it will be instructive to notice the appearance of the surface of the sand and silt that extend along the shore; for it is often deeply impressed with ripple-marks, produced by the action of the waves; and similar appearances will be presented to our notice on the slabs of limestone and laminated clays and shales of the wealden, and other ancient deposits.*

The sea-shore at Ryde, during the last century, has undergone a remarkable change in its geological character, which is worthy of attention. Sir Henry Englefield states that, "when Fielding, in the year 1753, was at

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* On a late visit to Ryde, the wind having a few hours previously been exceedingly variable, I found the ripple-marks formed on the surface of the muddy dunes by the agitated waters of a very remarkable character, and strikingly resembling the appearance of the limestone covered with fossil fuci from the Alleghany Mountains; and shortly afterwards I obtained from the Wealden at Sandown Bay a slab of shelly marble, with the upper surface rippled in precisely a similar manner.

Ryde, on his voyage to Lisbon, the town was totally inaccessible, except at or near high water, as the tide on its recession left a vast breadth of mud, which was too soft to bear the lightest weight. But this mud-bank is now almost covered by a layer of fine white sand, which has formed a surface smooth and firm enough to bear wheel-carriages, and which renders bathing at all times safe and agreeable. This bed of sand reaches to Binstead, having, during the last fifty years, covered two miles of the shore; and it is said to be still extending to the westward. To what cause this change is owing it is difficult to explain; but it is an example of an alternation of deposits from the action of the sea in circumstances apparently unchanged."*

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* Descriptions of the Picturesque Beauties, Antiquities, and Geological Phenomena of the Isle of Wight, by Sir Henry C. Englefield, Bart., 1816, p. 16.

CHAPTER III.

FRESHWATER EOCENE STRATA OF THE ISLE OF WIGHT—QUARRIES AT BINSTEAD—FOSSIL SCULL OF A REIN DEER—EOCENE STRATA AT BINSTEAD—FOSSIL CHARA—FOSSIL LAND AND RIVER SHELLS—FOSSIL TURTLES—FOSSIL REMAINS OF EXTINCT MAMMALIA.

Freshwater Eocene Strata.—The most remarkable peculiarity in the eocene formation of the Isle of Wight, as compared with that of London, consists in the lacustrine and fluviatile character of the upper series of deposits, which are superimposed on marine strata identical with those of the metropolis. For though in some localities clays and sands, containing marine and estuary shells, alternate with marls and limestones abounding in fluviatile species; and in others the strata are fluvio-marine—that is, contain an intermixture of marine and freshwater shells—yet throughout a considerable thickness of deposits the organic remains are entirely fluviatile and terrestrial. In this respect the tertiary system of the island corresponds with that of the Paris basin, which is characterised by alternations of freshwater marls, gypseous limestones, and siliceous millstones, with marine sands and clays. It was from the gypsum quarries of Montmartre that those relics of extinct mammalia were obtained, which the genius of the illustrious Cuvier called forth from their rocky sepulchres, and invested anew with the forms and lineaments of life.*

In the Isle of Wight the freshwater series consists of marls, limestones, and shelly concretions, with intercalations of clay, marl, and sand; the gypseous marls and limestones, and the siliceous millstones of the Paris group are altogether wanting. Nevertheless, there is evidence that the two formations were contemporaneous, for the relics of Cuvierian pachydermata have been discovered in the Binstead limestones. (See Pl. II.)

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* "Wonders of Geology," vol. i. p. 240.

The *freshwater* eocene strata of the Island, which are spread over the whole of the northern part, are denoted on the map (Pl. XX.) by *pink* on a plain ground; the *marine* beds appear on the surface as a narrow band extending along the northern flank of the chalk downs, and are indicated by the same colour on a ground shaded with parallel lines. The localities which exhibit the most instructive sections of the marine and freshwater deposits in their natural order of superposition are Headon Hill, Alum Bay, and Whitecliff Bay.

BINSTEAD QUARRIES.—The limestones in the vicinity of Ryde have been quarried for many centuries; the shelly, as well as the compact varieties, having been in great demand during the middle ages for building.* Though the sections exposed in the quarries now open are inconsiderable, they will suffice to illustrate the characters of the strata and the nature of their fossils, and render the interpretation of the phenomena hereafter to be examined more easy of comprehension. I would, therefore, first conduct the reader to Binstead, which lies about a mile to the west of Ryde. There are several quarries on both sides of the turnpike road to Newport, and others in a field which lies on the left of the footpath that turns off from the main road just beyond a Doric lodge, and leads by copses and hedge-rows to the picturesque hamlet of Binstead, affording here and there glimpses of the most charming rural scenery. The quarries for the extraction of the stone vary in depth from ten to twenty feet, and appear to have been opened, without regard to any regular plan, wherever it was thought a layer of compact stone could be easily reached.*

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* A great part of Winchester Cathedral is built of stone from the old quarries at Binstead. Some of the walls of Lewes Priory were faced with this stone, and several ancient Sussex churches are in part constructed of it. The variety composed of comminuted shells, held together by a sparry calcareous cement, was extensively used; it has been frequently mistaken for Caen stone by our antiquaries.

FOSSIL REIN-DEER.—Upon entering a quarry at Binstead, the dislocated state of the beds of limestone immediately strikes the observer. Vertical and diagonal fissures and chasms, extending in some places to the depth of fifteen feet, are seen traversing the solid rock, and filled with the alluvial loam and clay that form the general subsoil of this district; in these deposits bones of a species of horse and ox have been discovered. On a recent visit I obtained a considerable portion of the skull of a rein-deer (*Cervus tarandus*), from clay occupying the bottom of a vertical fissure at the depth of ten feet from the surface. It consists of the posterior part of the cranium, and closely resembles a specimen found in a cavern at Berryhead, in Devonshire, and figured by Professor Owen in *British Mammalia*;† the latter is referred by that eminent palæontologist to the recent species of rein-deer, chiefly from the proximity of the bases of the antlers to the occipital crest. Dr. Falconer, who, with his wonted courtesy, obliged me by comparing the Isle of Wight specimen with the skulls of recent deer in the British Museum, agrees with me in the opinion that there is no appreciable difference between the fossil cranium and that of the rein-deer. Lign. 4 * represents the specimen viewed from the occipital aspect; the figure is one-third the size of the original. The skull appears to have belonged to an adult that had but recently shed its antlers.

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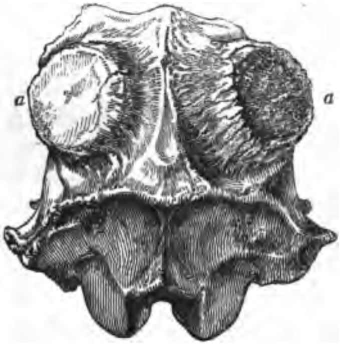
* *Quarr Abbey.*—In a sequestered valley, within a short distance of Binstead, are a few mouldering walls, the only remains of the once celebrated Quarr Abbey, which are generally visited by the tourist: the beauty of the scenery will amply repay the pedestrian geologist for the extension of his walk to this lovely spot.

† "British Fossil Mammals," p. 481, fig. 198.



LIGN 4.—FOSSIL SKULL OF A REIN-DEER, FROM A FISSURE IN A QUARRY AT BINSTEAD.

a. a. The osseous bases to which the antlers were attached.

(*One-third linear of the natural size.*)

EOCENE STRATA OF BINSTEAD.—The strata in this locality are entirely of freshwater origin, containing no intermixture whatever of marine detritus. This is evident from the fossils, which consist of shells of the common genera of mollusca that inhabit lakes and rivers; of seed-vessels and stems of aquatic plants; bones of freshwater turtles; and teeth and bones of land mammalia. An inspection of Plates I. and II. will give an idea of the assemblage of organic remains found in this locality. The layers of stone are commonly broken and dislocated, but not far removed from their original position. On my visit last summer, the following section was exposed in the principal quarry near the roadside; it presents the usual appearance and arrangement of the upper series of fresh-water strata of the island; the beds incline slightly to the north.

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* Engraved by Mr. Bagg, 63, Gower Street.

1.	Vegetable mould.	
2.	Alluvial loam and clay, in which are water-worn blocks of shelly limestone (but extending in fissures to a depth of 15 feet) . .	3 feet.
3.	Sand, with a layer of shelly limestone, more or less separated into blocks which are waterworn	2 feet.
4.	Shelly limestone, in thin layers . . .	1 foot.
5.	Very tenacious loam and clay, of a dark brown colour, much resembling in appearance the *dirt-bed* of the Isle of Portland . . .	1 foot.
6.	Fine sand, with comminuted shells . .	6 feet.
7.	Compact grey limestone, termed *siliceous* limestone by Mr. Webster, from its containing a large proportion of sand; but few fossils were observable	2 feet.
8.	Fine sand. Water issues from this bed, being thrown up (according to the quarrymen) by underlying beds of clay.	

The upper beds of limestone abound in casts and impressions of shells. No. 3 is full of hollows left by the decay of the shells, and the subsequent separation of the casts of their cavities. This bed appears to have been formed by the infiltration of calcareous matter into a layer of shells, the moulds and casts of which are now cemented together by sparry concretions. A coating of white powder on the casts is almost the only vestige of the constituent substance of the shells now observable. In this sparry limestone the minute seed-vessels of *charæ* hereafter described, fragments of bones of turtles, and casts of *planorbes* (Plate I. fig. 1) and *limnei* (Plate I. fig. 3) are abundant.

The sand, No. 6, is intimately mingled with comminuted shells, the whole being loosely held together by an infiltration of marl; the most coherent masses readily crumble into powder between the fingers. I have not succeeded in obtaining a single shell entire; but from a microscopical examination am led to conclude that the shelly particles are the detritus of the freshwater snails (*limnei*, and *planorbes*), so abundant in the limestone: waterworn bones of turtles occur in this bed. In some of the quarries there is a layer of very hard limestone entirely composed of comminuted shells cemented together by a crystalline calcareous infiltration; it contains extremely minute waterworn fragments of turtles' bones, and, very rarely, teeth and bones of mammalia. I believe this bed to be the equivalent of No. 3, from which it differs simply in its consolidation, and in the absence of sand and marl. This shelly limestone is observable in the walls of the most ancient castles and religious edifices in Hampshire and Sussex.

The siliceous limestone, or *rag*, as it is locally termed, being very compact and durable, forms an excellent building material. The upper limestones yield stone sufficiently firm for walls, &c., and are extensively quarried in the northern district of the Island. The surface of the blocks in newly-erected buildings often exposes such interesting groups of fossil shells, as to present a strong temptation to the geologist to trespass with his hammer.

I will now more particularly describe the fossils which occur in these strata. The shells, as we have seen, are very abundant, but they include only a few genera and species, a circumstance characteristic of fluviatile and lacustrine formations. With the exception of waterworn fragments of wood, the *Charæ* are the only fossil vegetables that have come under my notice. The mammalian remains are, at present, of excessive rarity; but I doubt not diligent research would soon add to the number already known to the palæontologist.*

FOSSIL CHARA.—The aquatic plant termed *Chara* is, of course, familiar to every one, as it abounds in lakes, streams, and rivulets, throughout the kingdom. The stems are hollow, and composed of tubes filled with a fluid in which green globules circulate. The fruit is a minute spherical body, enclosed in a calcareous integument formed of five spirally-twisted plates, which unite at the summit.† These fruits or seed-vessels, when first discovered in a fossil state, were supposed to be the shells of an unknown species of mollusk, and a genus was formed for their reception, and termed *gyrogonites*, or twisted stones, a name by which they are still often designated. These fossil bodies, from their extreme minuteness, are likely to elude the observation of the inexperienced collector, unless their structure and appearance are particularly noted; but a reference to the figures in lign. 5 will enable the reader easily to distinguish them with the assistance of a pocket lens.

On breaking the compact limestone the surface often appears studded with small spherical cavities, and these, with a lens of moderate power, will be found to present the inner surface of the pericarp or shell of the chara, the nut or kernel being absent. By a little practice some of these fossils may be obtained with the external surface exposed, and, rarely, with the nut in the shell, as in fig. 1, which is copied from Mr. Lyell's paper, in the "Geological Transactions." In the limestone at Whitecliff Bay, a species was discovered by Mr. Lyell, having the pericarp composed of nine spiral valves, covered with tubercles (fig. 2). On a recent visit to that locality, there were many blocks of limestone on the sea-shore, in which these bodies were so numerous as to constitute a large proportion of the mass, but I did not succeed in obtaining any specimens with the nut; the cavity of the pericarp was generally lined with calcareous spar. In some of the sands gyrogonites occur in abundance, and may be detected by examining with a lens a little of the earth spread out on a sheet of paper.

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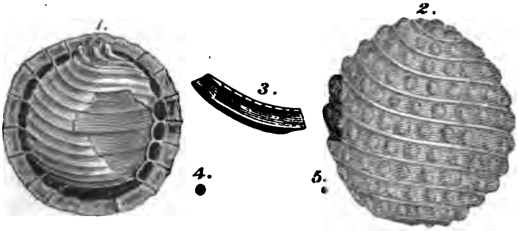
* I would refer the general reader, who is not conversant with the various conditions in which the remains of vegetables and animals occur in the mineral kingdom, according to the circumstances under which they were originally imbedded, and the chemical changes they may have subsequently undergone, to my remarks "On the Nature of Fossils or Organic Remains," chap. iii. "Medals of Creation," vol. i. See also "Instructions for the Collecting of Fossils," vol. ii. p. 885.

† "Medals of Creation," vol. i. p. 188.



LIGN. 5.—FOSSIL SEED-VESSELS OF CHARÆ.

(*Mr. Lyell.*)

Fig. 1.—*Chara medicaginula;* a section showing the nut within the pericarp.
2.—*Chara tuberculata;* the pericarp.
3.—Portion of a spiral valve, magnified.
4 and 5.—The natural size of figs. 1 and 2.

Fossil Shells.—The shells of Binstead are chiefly those of univalve gasteropoda, and belong to genera common in our rivers and lakes. The *Planorbis,* or discoidal river snail, (Pl. I. figs. 1, 2,) may be distinguished by the shell being involuted or coiled up in a nearly vertical plane; five or six species have been found. The *Limneus* (Pl. I. figs. 3, 4, 5) is characterised by its elongated oval form, pointed spire, and delicate shell, with an oblique fold on the inner lip of the aperture;[*] of this genus there are six species in the tertiary strata of the Island. The *Bulimus*,[†] a genus of land snails, is comparatively rare at Binstead, but casts of the large species, figured Pl. I. fig. 7, are occasionally met with, invested with a white friable coating of the original shell. This species is a reversed shell—that is, the aperture is to the left of the observer instead of to the right, as is most common; some specimens are two inches in length. There are indications of a species of *Cyclas*,[‡] a genus of freshwater bivalves, but the examples met with are not sufficiently perfect to require particular notice. A small species of *Unio*[§] is also sometimes found.

Specimens of the *Cypris*,[‖] a small freshwater crustacean, of which several species abound in some of the eocene deposits, occur at Binstead, but I have not observed them in any considerable number.

Fossil Turtles.—Waterworn fragments of the bony plates of chelonian reptiles, which, from their granulated or cancellated dermal surface, appear to have belonged to the group of soft freshwater turtles called *Trionyx*, are often found associated with the shells above described, in the tertiary limestones and sands of the Isle of Wight.

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[*] *Limnei* and *Planorbes* are generally joint inhabitants of our pools and streams. They are pulmoniferous—that is, possess air-breathing organs; hence they are obliged frequently to rise to the surface of the water to respire.

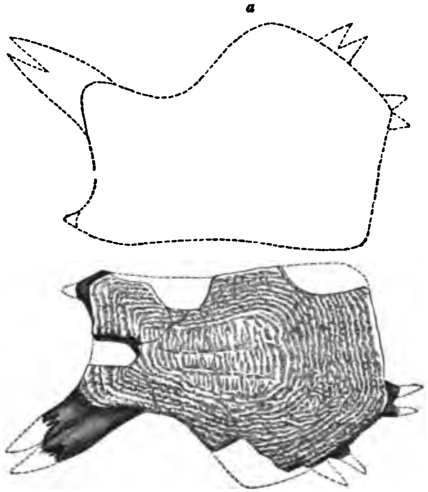
[†] *Bulimus* (properly *bulinus*) a genus of terrestrial pulmoniferous testaceous mollusca. These animals are herbiferous, and some of the species that inhabit warm climates are very large, their eggs being equal in size to those of the wren.

[‡] "Medals of Creation," p. 411.

[§] *Unio*, a genus of river mussels, of which a few fossil species have been observed in certain deposits, apparently of a fluviatile or lacustrine origin.

[‖] "Medals of Creation," p. 544.

It is very rarely, however, that any of the bones are sufficiently perfect to indicate the affinities of the original animal. The most instructive specimen I have obtained is the fossil represented in lign. 6; it is from the bed of sand marked No. 6, in the section p. 75, and when found was so thickly encrusted, that its characters were altogether concealed till the investing sand was removed.



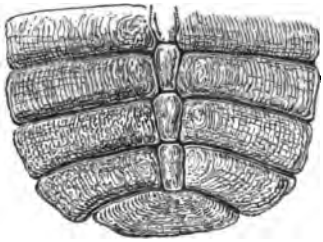
LIGN. 6.—STERNAL PLATE OF A FRESHWATER TURTLE, FROM BINSTEAD.

(One-third linear, the natural size.)

The outline, *a*, represents the corresponding portion of the plastron.

It is one of the bones (*meso-sternal*) of the *plastron*, or sternum, of a turtle belonging to the predaceous tribe of freshwater chelonians, termed *Trionyx*, from having three claws. This is evident from the peculiar form of the bone, and the cancellated outer surface, which is well represented in the lignograph: an outline of the corresponding portion is added to show the position of the bone in the sternum.*

That specimens of great interest and beauty may reward more active and judicious research than has hitherto been bestowed on the palæontological treasures of the island, is manifest from the discovery, a few years since, of one of the most remarkable fossil chelonians hitherto found in this country. It was obtained from the tertiary limestone that occurs in a low cliff near St. Helen's, a locality we shall hereafter notice, and was sold to a dealer, who afterwards disposed of it to a casual visitor. It consists of the entire *carapace* or buckler of a turtle, apparently of an adult *Trionyx*. It is sixteen inches in length, and about nine inches in its greatest width; and is formed of eight pairs of ribs, united by a dorsal series of eight plates. The ribs are of nearly equal breadth throughout their entire length, and have their dermal surface cancellated somewhat after the pattern of the meso-sternal plate figured in lign. 6. The buckler is as convex as in some of the land tortoises, and therefore differs greatly from the usual form of the carapace in the



LIGN. 7.—PORTION OF THE BUCKLER OF A FOSSIL TURTLE, FROM ST. HELEN'S.
(*Size of the original carapace, sixteen inches long and nine wide.*)

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* See "Medals of Creation," vol. ii. p. 766.

recent Trionyx, which is depressed, and has a soft flattened margin—a modification of structure enabling these animals to conceal themselves in the mud at the bottoms of rivers and lakes, and seize the mollusca which constitute their principal food.*

The only vestige of any other order of reptiles observed in these strata, is a tooth of the crocodilian type, apparently of the *Alligator Hantoniensis;* a fossil species described by Mr. Searles Wood, from a splendid specimen of the lower jaw and teeth, &c., found in the Freshwater beds at Hordwell Cliff, on the Hampshire coast.†

FOSSIL REMAINS OF EXTINCT MAMMALIA.—From the general correspondence between the tertiary formations of Hampshire and Paris, it is probable that these strata were deposited contemporaneously, and under very similar conditions, their respective basins being connected with the same sea, and alike characterised by alternations of marine and fluviatile sedimentary detritus. When, therefore, the attention of the scientific world was directed to the fossil mammalia found in the gypseous marls of Montmartre, in consequence of the extraordinary interest with which the late Baron Cuvier invested them, British geologists were sanguine in their anticipations of discovering traces of these extinct animals in the freshwater strata of England. But not a relic of this kind was found till some years after the appearance of the "Geograph. Min. des Environs de Paris." The first evidence of the occurrence of the extinct pachyderms of Paris in the British strata was obtained by Mr. Thomas Allan, of Edinburgh, who found a lower molar tooth of an *Anoplotherium* in a quarry at Binstead.[*] In 1830, Mr. Pratt discovered teeth and bones of *Anoplotherium, Palæotherium*, and *Dichobune*, in the same quarries.[†] Up to the present time eight species, belonging to four genera, have been discovered in the strata near Ryde. At Headon Hill a tooth and some bones have been found by Mr. Prestwich; and from the freshwater beds at Hordwell Cliff, on the Hampshire coast, the researches of Mr. Searles Wood have recently brought to light several interesting additions.[‡] The following list comprises the specimens hitherto discovered:—

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* I very much regret my inability to give a correct representation of the entire carapace; but having been promised the refusal of the specimen by the dealer, I contented myself with the sketch of the part here figured; the form of the bones, and the sculpturing of the surface are correctly shown in the lignograph.

† Of this most interesting specimen a beautiful representation is given in the first number of the new periodical, called "The London Geological Journal, or Record of Discoveries in British and Foreign Palæontology," published by Churchill.

ANOPLOTHERIUM *commune;* teeth (Pl. II. fig. 10) and bones; Binstead.
„ *secundarium;* teeth and bones; Seafield.[§]
CHÆROPOTAMUS *Cuvieri;* part of the lower jaw with teeth: Seafield; by Rev. W. D. Fox.
PALÆOTHERIUM *medium;* teeth (Pl. II. fig. 11); Binstead.
„ *magnum;* a tooth; Seafield; by the Rev. W. D. Fox.
„ *crassum;* teeth; Binstead and Seafield.
„ *minus;* right ramus of the lower jaw with five molar teeth (Pl. II. fig. 12); portions of the skull, radius, and tibia; Seafield, near Ryde; by the Rev. W. D. Fox.
DICHOBUNE *cervinum;* lower jaw and teeth (Pl. II. fig. 13); Binstead; by Mr. Pratt.

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[*] This specimen was figured and described by Dr. Buckland, in the "Annals of Philosophy," 1825.

[†] "Remarks on the Existence of the Anoplotherium and Palæotherium in the Freshwater Formation at Binstead," by Samuel Peace Pratt, Esq., F.R.S. "Geol. Trans." vol. iii., new series.

[‡] See "London Geological Journal," No. 1, pp. 5, 6.

[§] Seafield is a little hamlet to the east of Ryde, but the quarries are not accessible to strangers.

All the fossils in the above list are figured and described by Professor Owen in "British Fossil Mammals,"* a work of the highest interest, replete with the most profound views of the correlation of animal organisation, and therefore of inestimable value to the palæontologist. I have introduced figures of a few teeth in Pl. II., that the reader who visits the Binstead quarries may be aware of the appearance and characters of these relics. The lower jaw of the *Palæotherium minus*, with five molar teeth (Pl. II. fig. 12), is a highly instructive specimen.†

It is unnecessary to enter at large on the structure and habits of the pachydermata to which these remains belonged; for even the forms of these extinct beings must be familiar to the reader, as Cuvier's restorations of several species are introduced into every popular work that treats of the ancient inhabitants of our globe.‡ The *Anoplotheria* are remarkably distinguished by having feet with but two toes, as in the ruminants, and an uninterrupted dental system; the teeth being placed in a continuous series, as in man, without any interval between them. The *A. commune* was eight feet long, and of the height of a wild boar, but of a more elongated shape. It had a long and thick tail which, it is supposed, like that of the otter, assisted it to swim with facility; from the structure of the teeth it is inferred that it browsed on grass like the horse. The *A. secundarium* was a smaller species. The *Chæro-*

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* "A History of British Fossil Mammals and Birds. By Richard Owen, F.R.S.," &c. 1 vol. 8vo, with numerous illustrations. Published by Van Voorst, London, 1846.

† The Palæotherium had seven molar teeth on each side the lower jaw. In the specimen figured three true molars, and two of the premolars remain; the seventh or last molar has three crescent-shaped lobes; the others but two each.

‡ The details of their anatomical structure are given in Cuvier's "Ossemens Fossiles," tom. iii.

potamus was of the hog tribe, and nearly related to the peccari, but one-third larger. The *Palæotheria* resembled the tapirs in the form of the head, and in having a short proboscis, but their molar teeth were more like those of the rhinoceros; their fore-feet had but three toes, instead of four, as in the tapirs. Upwards of eleven species, varying from the size of the rhinoceros to that of the hog, have been discovered in the tertiary strata of France. The *P. magnum* was of the size of a horse four or five feet high, with a massive head and proboscis, and short extremities. The *P. medium* was one-sixth smaller than the American tapir, but had longer and slighter legs and feet. The *P. minus* was an elegant creature of the size of the roebuck, with light and slender limbs. The *Dichobune* is related to the Anoplotherium, but characterised by the peculiarity of its dental system, which approaches that of the ruminants in the cusps of the molars having a tendency to form a double series of crescents. (See Pl. II. fig 13.*)

We must here terminate our investigation of the strata exposed in the quarries near Ryde, and proceed to the eastern end of the Island, to examine the marine deposits that underlie the fluviatile and lacustrine strata, to which our attention has hitherto been exclusively directed.

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* In "Brit. Foss. Mam." (p. 440) beautiful figures are given of portions of a lower jaw with teeth, found at Binstead, by Mr. Pratt.

CHAPTER IV.

FROM RYDE TO CULVER CLIFF—GEOLOGY OF WHITECLIFF BAY—STRATA AND ORGANIC REMAINS—SANDOWN BAY—BONES OF COLOSSAL REPTILES.

From Ryde to Culver Cliff.—On the north side of Culver Cliff, the eastern extremity of the chalk downs and of the Island, the long-continued action of the sea on the tertiary strata has excavated an irregular bay, which is bounded by cliffs that expose a section of the entire series of marine and freshwater eocene deposits. This excavation is called Whitecliff Bay, and is about nine miles from Ryde. *

The road from Ryde passes over a country prettily diversified by gentle hills and dales; but the strata are concealed by pasturage and cultivation, and the geological character of the district can only be traced in the low borders along the sea-shore, and in the pits and quarries opened for the extraction of limestone for economical purposes. The whole of this tract consists of freshwater marls, clays, sands, and limestones, like those of Binstead. As we approach Brading, the chalk downs which form the horizon rise up in bold relief, and flank the tertiary strata on the south. On the summit of this line of hills is the signal tower on Ashey Down, which forms a conspicuous object in the landscape.

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* See the diagram, Pl. VII. p. 67; and the map, Pl. XX. The reader will remember that Whitecliff and Alum Bay are natural sections of the vertical and horizontal tertiary strata that extend through the Island from east to west, on the north of the chalk downs.

The picturesque town of Brading, with its venerable church,* stands on a low ridge of chalk; and in descending the gentle declivity beyond, the highly-inclined position of the chalk may be perceived in the bank on the right hand, the layers of flint being nearly vertical. As we proceed, the marl, firestone, and galt appear, and are succeeded by the ferruginous sands belonging to the lowest group of the cretaceous system, and which continue to the sea-shore at Sandown. But our route lies to the left, and we pass by cuttings of chalk and marl, Brading Haven being spread out before us on the left, till we approach Yaverland Church,† which stands on a little knoll overshadowed by elms, near the foot of Bembridge Downs. From this spot there is a narrow road to some fields on the north of the hill, through which a path leads to the brink of the precipitous cliff that overhangs Whitecliff Bay, near the junction of the chalk and eocene strata. Here a very steep foot-track winds down the face of the cliff, which is covered with ferns and brush-wood to the sea-beach. But the main road leads to Bembridge,* and Whitecliff is reached by a walk of nearly two miles along the shore. After much rain, however, the bay is scarcely accessible, for mud and sand-banks obstruct the way, and the slippery state of the ground renders walking most wearisome.

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* Brading Church. This interesting edifice is supposed to have been erected soon after the Conquest; but independently of its claims as an object of antiquity, it deserves notice from having been for many years the scene of the pastoral labours of the late Rev. Legh Richmond. The admirers of that interesting author who visit the island should procure the cheap and elegant little hand book to the scenes described in the "Annals of the Poor," entitled "The Landscape Beauties of the Isle of Wight, as described by the late Rev. Legh Richmond; by George Brannon."

† Yaverland Church is supposed to have been erected in the twelfth or thirteenth century. It was in this church that Legh Richmond made his first attempt to preach extempore, and completely failed, though he was afterwards celebrated for the power and eloquence of his extemporaneous discourses. This interesting spot is graphically described by Mr. Richmond in "The Dairyman's Daughter." "It is pleasantly situated on a rising bank at the foot of a bold chalk hill, and being surrounded by trees, has a rural and retired appearance. Close to the churchyard stands a large and ancient mansion, which was formerly the residence of an opulent and titled family, but has long been appropriated to the use of the estate as a farm-house. Its outward aspect bears considerable remains of ancient grandeur, and gives a pleasing character to the spot of ground on which the church stands. In every direction the roads that lead to this sacred edifice possess distinct but interesting features. One of them ascends between several rural cottages from the sea-shore, which adjoins the lower part of the village street; another winds round the side of the adjacent

GEOLOGY OF WHITECLIFF BAY.—From Bembridge the tower of an ancient church, painted white, and serving as a land-mark, is seen on the opposite side, on the northern point of the haven; the pretty village of St. Helen's, embosomed in trees, stands on the brow of the neighbouring hill. A low cliff, composed of freshwater strata, may be observed near its base; and from this locality the fossil turtle, described in p. 81, was obtained. The cliffs immediately beyond Bembridge are from twenty to thirty feet high, and consist of alluvial gravel and clay, resting upon freshwater strata; the ledges and rocks on the sea-shore are denuded waterworn masses of the limestone that have fallen from the cliff. After passing the Foreland, and proceeding a few hundred yards along the shore, the tertiary calcareous deposits form the base of the cliffs, and lie in a nearly horizontal direction; but towards the northern extremity of the bay they gradually rise, and at length are bent upwards in a curved position, and rest

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hill; and a third leads to the church by a gently rising approach between high banks covered with young trees, bushes, ivy, hedge-plants, and wild flowers."

* There is a good hotel at Bembridge, and a passage ferry across the mouth of Brading Haven to St. Helen's.

somewhat unconformably on the almost vertical beds of clay.* This is the point of junction of the freshwater and marine series of the Isle of Wight eocene deposits. The cliff now entirely consists of the London clay beds, which are exposed wherever there is a break or slip in the turf-coloured slopes. These strata become more developed towards Culver Cliff, where the lowermost tertiary, and uppermost cretaceous strata, are in juxta-position.

The magnificent chalk cliffs of Culver can only be seen to advantage from the sea (see Pl. XIV.); the dip of the beds is about 70° to the north, and is well defined, even from a distance by the layers of flints. Most of these siliceous nodules, though imbedded in the chalk, and still retaining their original forms, are splintered to atoms, probably from the concussion produced by the upheaval of the strata: this phenomenon was first pointed out by Sir Henry Englefield.†

Whitecliff Bay, though destitute of those remarkable characters which have rendered Alum Bay so attractive to the tourist is highly interesting to the instructed observer. From the period when Sir H. Englefield and Mr. Webster first directed attention to the phenomena here exhibited, this locality has been explored by many eminent geologists,‡ and the mineralogical character, organic remains, and order of succession of the strata, have been accurately determined.§ But a few months since an elaborate and important memoir, with ample illustrations and details, was laid before the Geological Society by Mr. Prestwich.* In the present work a concise view of the most interesting facts is alone admissible, and which the annexed diagram (lign. 8), from a section exhibited by Mr. Prestwich, will serve to render intelligible.

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* A beautiful sketch of this part of the cliffs is given in Pl. XV.; and of the bay, in Pl. XVII., No. 1, of Sir Henry Englefield's "Isle of Wight."

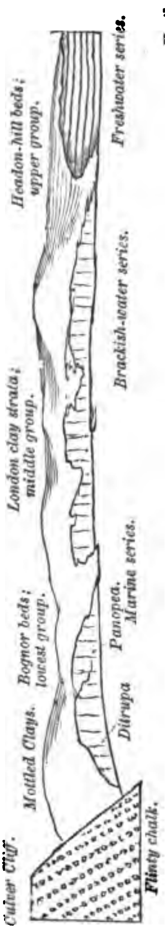
† See "Linnæan Transactions," vol. vi. p. 108; also "Fossils of the South Downs," p. 151.

‡ In 1822 Mr. Lyell made an accurate examination of this cliff, and favoured me with a series of specimens, and a detailed section of the strata.

§ See list of publications relating to the Geology of the Isle of Wight in the Appendix.

The eocene strata in Whitecliff Bay appear in the same order of superposition as at Alum Bay, as we shall point out when we visit that locality; but the cliffs before us are less precipitous than those in the north-west of the Island, and their slopes are covered by debris, and in many places with vegetation, down to the shore.

The eocene deposits of the Isle of Wight, according to the investigations of Mr. Prestwich, may be regarded as forming three principal groups—viz., the upper freshwater series, and the marine series, which is divisible into the *London clay* and the *Bognor deposits*.† (See lign. 8.)



LIGN. 8.—DIAGRAM OF THE EOCENE STRATA AT WHITECLIFF BAY.

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* Since published in the "Quarterly Journal of the Geological Society," Aug. 1846.

† The Bognor fossils were first mentioned by Mr. Webster; a more extended notice was published in my "Fossils of the South Downs," and "Geology of the South-East of England." "The

THE STRATA AND ORGANIC REMAINS.—If we retrace our steps from Culver Cliff towards the Foreland, we find that the lowermost tertiary strata, those in actual contact with the chalk, consist of *mottled plastic clays*, in which no vestiges of animal remains have been observed. These are followed by a brown sandy clay, with septaria, &c., and a series of sands, sandstones, and clays which abound in species of shells of certain genera, long known to prevail in the strata that emerge along the western coast of Sussex, and particularly at Bognor; the rocks on the shore at that watering-place consisting of coarse sandstone full of similar fossils. The lowermost or earliest bed of this series is a layer of brownish clay with green sand (in some parts passing into concretionary sandstone) almost made up of the tubular shells of one species of pteropodous mollusk, the *Ditrupa plana*, formerly called *Dentalium planum* (Pl. III. fig. 3); the Bognor rocks are full of these shells. The clays and sands that succeed swarm with certain marine bivalves (*ostrœ, myœ, turritellœ, pectunculi*), which also occur at Bognor. The *Panopæa intermedia* (Pl. III. fig. 5) is a very characteristic fossil.*

A considerable thickness of variously coloured sands and clays, in which no organic remains have been found, is next in order; and then the suite of deposits of the London clay teeming with marine exuviæ. Among the shells are

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rocks at Bognor are evidently the ruins of a deposit once very extensive, and which, even within the memory of man, formed a line of low cliffs along the coast; at present a few groups of detached rocks, covered by the sea at high water, alone remain, and the period is not far distant when these will be swept away by the action of the waves. These beds are decidedly analogous to the *calcaire grossier* of Paris."—"Geol. S. E. of England," p. 51.

* The position of the strata containing the *Ditrupa* and the *Panopæa* is shown in the diagram, lign. 8. A few weeks since several blocks of the greenish limestone, covered with *Ditrupæ*, were lying on the beach near the spot indicated.

the species figured in Pl. III. figs. 1, 2, 4, 6, 7. The *Cardita planicosta* (fig. 7) is a strong and thick bivalve that abounds in some of the argillaceous beds, and often attains a large size.* Shells of the genera nummulites,† Venus, ancillaria, voluta, cerithia, &c., occur in immense numbers;‡ and in the greyish blue clay are myriads of minute species. Teeth and bones of fishes, and of reptiles, and remains of crustaceans (crabs, lobsters, &c.) are occasionally found. In the upper beds of the London clay, *lignite* (carbonised wood), and shells of certain genera which inhabit estuaries (*Melanopsis*, Pl. II. figs. 3, 6), and some freshwater species are met with, indicating that the strata were deposited in brackish water. These are the uppermost of the highly inclined marine beds at Whitecliff Bay.

The freshwater series next appears; but in the lowermost division of this group there is an intermixture of estuary and marine shells: these deposits would therefore be more correctly designated *fluvio-marine.* Calcareous marls, sandstones, and limestones, abounding in fluviatile and lacustrine shells, similar to those of Binstead, form the succeeding portion of the cliff. On a recent visit the fallen masses of rock were full of fossil seed-vessels of charæ (*C. tuberculata*, lign. 5, p. 78). Some of the upper strata are of a fluvio-marine character; and within 100 feet of the superior layer there is a seam of oyster-shells in a bed of marl near the top of the cliff at Bembridge ledge, which was pointed out by Mr. Lyell in 1824.

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* At Bracklesham Bay, on the western coast of Sussex, the clay, at low water, is in many parts literally paved with these shells, and great numbers may be collected in a very short space of time. Bracklesham is also prolific in numerous other fossils of the London clay. In 1821 I made a considerable collection of the organic remains of this part of the Sussex coast, and published a list of them in the "Fossils of the South Downs," and a more extended one in the "Geology of the South-East of England." But of late years diligent research has brought to light numerous fossils of great interest; and besides many new species of shells, vertebræ and bones of fishes, serpents, turtles, and crocodiles have been collected. For an excellent notice of this locality, by Mr. Bowerbank, see "Medals of Creation," vol. ii. p. 903. Mr. Dixon has a splendid collection of the Bracklesham fossils, comprising several new species of *Miliobatis* (eagle-ray), *Aëtobatis*, and other genera of the *Rays*. Spines of these fishes, and of a species of *Silurus*, have also been discovered.

† *Nummulites*, a fossil polythalamian shell, of a discoidal flattened form, resembling a coin; hence the name. See "Medals of Creation," p. 242.

‡ A chisel, as well as a hammer, and a pickaxe to break up large masses of the stiff clay in which the shells are imbedded, will be required to extract perfect specimens.

There are several layers of pebbles in the marine vertical strata; and in some of the calcareous sandstones of the upper series pebbles and angular fragments of flint are imbedded, alternately with seams of freshwater shells.

The total thickness of the eocene strata at Whitecliff Bay is about 650 yards;* of which, according to the measurements of Mr. Prestwich, the mottled clays are 142 feet; the Bognor series about 300 feet; the London clay 930 feet; and the fluvio-marine and freshwater group 550 feet.

The assemblage of organic remains in these deposits is regarded by Professor E. Forbes as indicating the following sequence of changes in the condition of the basin in which they were formed. This fauna, which did not begin until after a considerable thickness of mottled clays, in which no traces of animal organisation appear, had been deposited upon the chalk, commences by numerous peculiar myaform shells, pectunculi, ostreæ, and their associates, in a series of sands and clays. The earliest fossiliferous bed is a most remarkable one, consisting of a thin stratum, almost entirely composed of the shells of a pteropodous mollusk (the *ditrupa plana*, Pl. III. fig. 3), which appears to have continued but a short specific time in life, and to have entirely disappeared. In the midst of this group, strata charged with myriads of foraminifera (*nummulites*), probably indicating some change in the depth of the sea, appear, and cease. The sudden conversion of the sea into a freshwater lake, denoted by a stratum of paludina clay—its return into a brackish state, and the consequent reappearance of certain marine animals—its reconversion into a freshwater lake thronged with myriads of fluviatile mollusca (*planorbes, limnei*)—and the almost momentary influx of salt water during that period, which lasted only long enough for a race of oysters to live and die away—all render the tertiary strata in this locality of high interest."*

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* Where the beds are vertical, the horizontal distance of course expresses the thickness of the deposits.

It may assist the collector to state that the *ditrupa* bed is exposed in the cliff at the distance of from 45 to 50 paces from the junction of the lowermost tertiary clay with the chalk. At 150 paces further, towards Bembridge, are greenish grey sands and clays, in which the *cardita planicosta* (Pl. III. fig. 7), and numerous other marine shells occur; and about 200 paces onwards similar shells, with large nummulites, volutes, cerithia, &c., are abundant in strata of the same character.†

SANDOWN BAY.—To pursue the natural order of our inquiry, we should now retrace our steps to Ryde, and proceeding to the north-western extremity of the Island, examine the corresponding phenomena in Alum Bay. But it may be more convenient to the visitor if we first conduct him to the southern side of Culver Cliff, where a natural section of the strata of the cretaceous system (see table, p. 43), and of the upper Wealden deposits, constitutes the line of cliffs forming the boundary of Sandown Bay. (See the map, Pl. XX.)

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* "Report of the Fourteenth Meeting of the Brit. Assoc. of Science for 1844." Transactions of the Sections, p. 44.

† See an interesting paper "On the London and Plastic Clay Formations of the Isle of Wight," by J. S. Bowerbank, Esq., F.R.S. Geol. Trans.

But we shall restrict our remarks to a very general description of the geological structure of these cliffs, and reserve a particular account of the chalk and Wealden formations till we enter upon the examination of the south-western localities of these deposits.

From Bembridge we return to the foot of the Downs by Yaverland Church,* and thence through the village to the sea-shore, near the centre of Sandown Bay, the distance from Yaverland scarcely exceeding a mile.† It is desirable to alight before we reach the Fort, and as near to the coast as possible, and then proceed along the strand towards the eastern end of the bay.‡ The annexed sketch, from the accurate sections of Dr. Fitton, will convey a general idea of the relative position of the strata.

The distance comprised in the section is between four and five miles. Shanklin Down forms the western, and Bembridge Down the eastern limit. On the eastern side of the bay the flinty chalk has a total thickness of about 200 feet; the *lower chalk* and *chalk marl*, 200 feet; the *firestone* 100 feet; and the *galt* 50 feet. The *greensand* beds that follow correspond with those of

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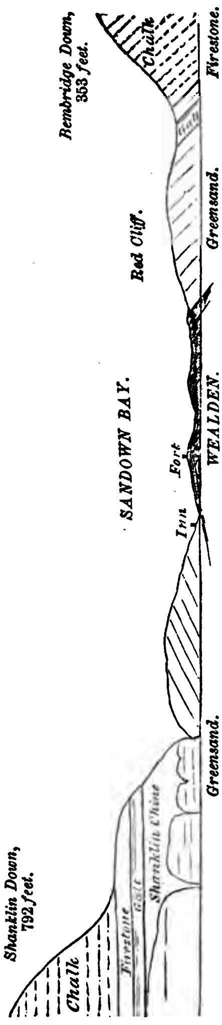
* There is a small chalk-pit on the side of the hill worth examination, as it well displays the highly-inclined position of the chalk and flint strata.

† The stranger must not attempt to go round the headland of Culver Cliff by the strand, even at low water; Sandown Bay can only be safely reached in a boat, except by the road described in the text.

‡ At the village of Sandown there is an inn where refreshment may be obtained for "man and horse." The coach from Ryde to Ventnor stops at the King's Head, near the sea-shore, where the geologist travelling by this conveyance should alight.



LIGN. 9.—SECTION FROM SHANKLIN TO BEMBRIDGE DOWN, ACROSS SANDOWN BAY; 4½ MILES.
(*From Dr. Fitton's Sections; Geological Transactions, Vol. IV.*)

Atherfield cliffs, which we shall hereafter visit, and contain similar fossils; the lowermost bed abounding in that remarkable and characteristic shell, the *Perna Mulleti* (Pl. IV. fig. 6). The Wealden deposits occupy the middle of the bay; and on the west, the sands and clays of the greensand reappear, and form the cliffs from Sandown to Shanklin, where they are covered by the galt, firestone, chalk-marl, and flinty chalk; the latter attaining an elevation of nearly 800 feet. Sandown Bay comprises, therefore, a double series of the strata of the cretaceous system thrown into an anticlinal * position by the elevation of the Wealden, which constitutes the axis of this line of coast.

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* The anticlinal axis and order of superposition of the strata at Sandown Bay, and the correspondence of these deposits with the Wealden and cretaceous systems of Sussex and Surrey, were ascertained more than twenty-four years since by Mr. Lyell, and communicated to me in a letter dated Bartley Lodge, July, 1822, accompanied by a section from Culver Cliff to Shanklin Down, and a suite of specimens comprising examples of all the principal deposits. This collection is now in the British Museum.

Along the middle of the bay opposite the Fort the subsoil, except after very heavy tides, is concealed by a thick bed of shingle.*

RED CLIFF.—On proceeding eastward a low bank appears, and the coast gradually rises to the lofty hills of Red Cliff. The strata first accessible to observation are the ferruginous sands and mottled clays belonging to the Wealden formation, which become more developed as we advance towards the chalk strata that terminate in the bold promontory of Culver, which forms a striking object from this part of the bay. In the shingle may be found rolled blocks and pebbles of the Wealden shelly limestones; and of jasper and quartz, with rolled silicified zoophytes that have been washed out of the chalk.

In the Wealden, bones of large reptiles, and fruits of coniferous plants, have from time to time been discovered; and many colossal bones of the Iguanodon have been obtained from the shingle. Slabs of the paludina-limestone (see Pl. VI. fig. 3), commonly called Sussex marble, and of indurated shale full of fresh-water bivalves (Pl. VI. fig. 4), may generally be seen protruding from the clay.† Masses of lignite that have fallen out of the cliffs are often found on the beach, and sometimes pebbles of silicified wood. A few hundred yards before we reach the chalk strata, laminated clay and shale appear in the face of the cliff, and the surfaces of most of the laminæ are studded with myriads of the cases of minute fresh-water crustaceans, termed *cyprides* (see lign. 25), belonging to two or three species which are peculiar to the Wealden deposits.

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* In the section, for the sake of perspicuity, the Wealden strata in the middle of the bay are represented more lofty than they actually appear; for, in general, the sea-beach extends over the whole surface. But after sweeping spring tides in the early months of the year, the clay and sands are exposed as here represented.

† In a late visit to this spot (August, 1846) a layer of Sussex marble, having a band of fibrous calc-spar, an inch thick above and below, was exposed in the clay near the base of the cliff.

It is only after recent slips of the cliffs from the inroads of the sea, that the beds are clearly exposed, and after heavy rains, that the fossil bones are brought to view by the washing away of the clay in which they are imbedded; but at all times instructive specimens of the strata, and of the usual species of shells, may be obtained. The greensand and galt are not so prolific in fossils as in some other localities; but the marl and firestone contain many organic remains characteristic of those beds.

BONES OF THE IGUANODON, &c.—The occurrence in this locality of bones of the Iguanodon and other reptiles whose remains had previously been observed only in the strata of Tilgate Forest, was first made known in 1829 by the present Dean of Westminster, Dr. Buckland. An enormous toe-bone (*metatarsal*), weighing six pounds, and measuring six inches in length, and sixteen inches in circumference at its largest extremity, was found in the ledges of ferruginous sand, a little to the east of Sandown Fort.* A considerable number of bones, comprising several gigantic vertebræ, portions of a femur or thigh-bone, fragments of ribs, &c., were discovered near the same spot, at the foot of the low cliff that forms the sea boundary of Yaverland farm. They were observed on the shore after a week of very stormy weather, which had swept away the beach and sand to the depth of two feet, and thus laid bare the fossils, which probably had fallen from the cliffs long previously, and being very heavy, had sunk deep into the shingle, and lain concealed till brought to light by the denuding effects of the storm. In the adjacent cliff of grey sandstone interspersed with clay, several cones of a plant allied to the *Zamiæ*, mixed with fragments of lignite, have been discovered.*

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* "Geol. Trans." vol. iii. p. 425.

We now return to Ryde that we may proceed to the north-western part of the Island, and examine the eocene strata at Alum Bay and Headon Hill.

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* One of these fossil fruits is figured and described in "British Fossil Flora," under the name of *Zamia crassa;* and in "Medals of Creation," vol. i. p. 160.

CHAPTER V.

FROM RYDE TO NEWPORT—THE RIVER MEDINA—NEWPORT TO CALBOURNE AND ALUM BAY—THE COAST FROM RYDE TO ALUM BAY—HEADON HILL AND ALUM BAY—GEOLOGY OF HEADON HILL AND ALUM BAY—SEQUENCE OF GEOLOGICAL CHANGES—ORGANIC REMAINS—YARMOUTH AND LYMINGTON—CHRISTCHURCH BAY—STRATA OF HORDWELL CLIFFS—HORDWELL FOSSILS.

FROM RYDE, THROUGH NEWPORT, TO ALUM BAY.—From Ryde, the journey to Alum Bay may be performed either by land or sea. The road passes by Binstead, and through the picturesque village of Wootton-bridge, to Newport, the capital of the Island. In the rooms of the Newport Institution, there is a miscellaneous collection of organic remains; but it is much to be regretted that a complete series of specimens, illustrative of the geology of the Isle of Wight, is not to be met with in this or any other town in the Island.

Newport is situated on freshwater eocene strata, which are a continuation of those of Headon Hill, and lie in a nearly horizontal position; the wells in the town are sunk through these beds, to the depth of 200 feet. At Parkhurst barracks a well was dug through 300 feet of London clay, containing a few thin seams of shells. On examining the nature of the soil in the tract between the town and the neighbouring chalk hills, the vertical* marine strata are found occupying the same relative position as at Whitecliff Bay. In a heap of clay that had recently been dug up from the bottom of a well, Mr. Webster discovered vestiges of coleopterous insects; and obtained several fossil seed-vessels of a plant related to the *Meadow-rue* (*Thalictrum*); they consisted of the pericarp, in a carbonised state, filled with clay.*

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* Mr. Webster notices a clay-pit, opened for a brick manufactory, in which were clay and sand strata in a nearly vertical position, and the upper portions contorted as if from pressure. Sir H. Englefield's "Isle of Wight," Pl. XXXIV. fig. 1.

The quarries in the neighbouring chalk down of Mountjoy, to the southward of the town, expose some interesting sections of the highly-inclined strata of chalk and flint; and the summit of the hill commands a most extensive and delightful prospect.

River Medina.—The Medina river, which rises at the foot of St. Catherine's Down, and divides the island into two nearly equal portions, called the East and West Medina, flows through a transverse valley of the chalk range on the south, and winding round the east end of the town, becomes navigable for vessels of considerable burthen, to its entrance into the sea at Cowes. The valley of the Medina, like the river valleys of the North and South Downs,† is a transverse dislocation, or rent, across the range of chalk hills, produced by the tension of the strata during their elevation from the horizontal to their present nearly vertical position.

The transverse course of the Medina through the middle of the central ridge of chalk, is noticed by Mr. Hopkins in his memoir "On the Geological Structure of the Wealden District, and of the Bas Boulonnais,"‡ with the accompanying diagram, lign. 10, which represents an east and west section of the valley near Rookley, about four miles south of Newport. “It presents,” observes Mr. Hopkins, “a north and south line of flexure which must almost necessarily be accompanied by a corresponding north and south fracture, in which I conceive the valley to have originated.”

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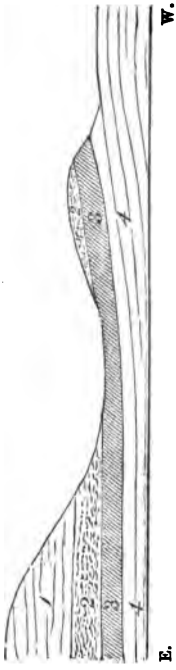
* A figure of this fruit (which has been named by M. Adolphe Brongniart, *Thalictroides Websteri,*) is given in the "Medals of Creation," vol. i. p. 190.

† "Geology of the South-east of England," p. 350.

‡ "Geol. Trans." vol. vii. p. 24.



LIGN. 10.—SECTION OF THE VALLEY OF THE MEDINA FROM EAST TO WEST; NEAR BOOKLEY.

(*By Mr. Hopkins.*)

1. Chalk.—2. Firestone.—3. Galt.—4. Greensand.

NEWPORT TO CALBOURNE AND ALUM BAY.—From Newport the road passes through the picturesque and interesting village of Carisbrook, and near the venerable castle, which stands on an eminence of chalk, on the left;* and from thence to Calbourne, a little village, five and a half miles from Newport. In the vicinity of Calbourne there are several quarries of freshwater limestone, where the stone is extracted for building and agricultural purposes. The shells in the limestone of this part of the island are generally in a much better state of preservation than those found at Binstead. The finest specimens in my collection were obtained from the quarries at Calbourne, Shalfleet (a village on the Yarmouth road), and on Dodspit farm, about one mile and a half beyond Calbourne, in the same direction. In a pit opened in a field near the farm-house at the latter place,* the limestone was peculiarly rich in those species of land and river shells that are rare at Binstead. The snail-shell (*Helix globosus*), figured Pl. II. fig. 7, and the *bulimi*, *paludinæ*, *limnei*, and *planorbes* (Pl. I.), are of a large size, and very perfect. Occasionally the shells are preserved; but, for the most part, sharp casts alone remain. The limestone occurs in large concretionary masses, forming regular beds of moderate thickness in calcareous marl; the strata have a slight northerly dip.

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* Carisbrook Castle, so interesting to the tourist, from the historical events with which it is associated, was founded in the time of Edward IV. The gateway, with its round towers at the angles, and machicolated battlements, resembles the Castle gateway at Lewes, which was erected by John Earl de Warren, *temp.* Edward III. See “A Day's Ramble in and about the Ancient Town of Lewes,” p. 109.

The well at Carisbrook Castle is said to be 300 feet deep; it probably reaches the chalk-marl, which is in general the first water shed when the white chalk is perforated.

From Calbourne † the road inclines to the left, and continues in a line nearly parallel with the chalk range through Chessel and Afton to the foot of the downs that extend to the western extremity of the Island.

Soon after leaving Carisbrook these hills are seen forming the distant horizon, their outline appearing as three distinct eminences. That on the left is the chalk range of High Down, above Freshwater-gate, attaining an altitude of 700 feet; the middle eminence is the hill to the east of the vertical strata of Alum Bay; and that on the right, or north side, is Headon Hill, which is 400 feet high. The road passes within half a mile of Freshwater-gate, and winds up a steep ascent to the summit of the down, where a splendid and extensive prospect suddenly opens on the view. On the right is Headon Hill, separated from the eminence on the left, Alum Bay, by a deep chasm; and on the extreme left is the lofty chalk ridge of High-Down, which extends westward into the sea, and terminates in the isolated wedge-shaped masses of chalk, called the Needles. In the remote distance, on the opposite shore, the chalk cliffs, near Swanage, in the Isle of Purbeck, may be distinguished; and likewise the low line of tertiary cliffs on the Hampshire coast, by Barton and Hordwell. On the north-west brow of the hill, commanding a fine view of the entrance of the Solent sea, is Grove's Hotel; a very convenient resting-place for a short sojourn.* From this spot there is a footpath along the north side of the chasm that separates Headon Hill from Alum Bay, which leads to the sea-shore, near the point of separation between the horizontal and vertical eocene deposits. Pl. VIII. is a view from the right-hand side of the hill, about half-way down, showing the vertical face of the chalk cliff which bounds the bay on the south, and extending westward, terminates in the Needles. The Isle of Portland is dimly visible in the remote distance.

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* In the summer of 1844.

† Calbourne Church is an interesting edifice, of early Norman architecture. There is a little inn in the village, and, if the visitor's time permit, a day may be well spent in examining the quarries in the localities mentioned; a rich collection of the eocene freshwater fossils may with certainty be obtained.

THE COAST FROM RYDE TO ALUM BAY.—The steam-packets from Ryde to Yarmouth and Lymington pass sufficiently near the northern shore of the Island to afford a general view of the outcrop of the strata in the cliffs and bays formed by the inroads of the sea, and at the mouths of the rivers and estuaries. The coast from Ryde to Cowes presents no features of particular geological interest. Here and there slips or subsidences in the low cliffs have exposed beds of calcareous marl and freshwater limestone, covered by alluvial clay and loam, along the sea boundary of Her Majesty's demesnes of Osborne, and of the grounds of Norris Castle.* Along the shore at low water numerous fossil shells washed up by the sea are often to be met with.

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* The intelligent landlord has a small collection of fossils, gathered from the neighbouring cliffs; it contained several interesting specimens when I last inspected it.

On the north side of Gurnet Bay, about two miles to the west of Cowes, the cliffs are composed of alternating beds of clay and limestone, the latter abounding in fresh-water shells (especially in *potamides*, Pl. II. figs. 2, 8, 9,) and *gyrogonites*. In Thorney (or Thorness) Bay, similar strata are exposed, with layers of blue clay and sand, containing marine shells.† In several localities along the northern shores of the Island, as for instance, between Ryde and Cowes, and near Cowes, fluvio-marine clays appear on the sides of the sloping banks; but the exact stratigraphical position of these beds is concealed by vegetation; they are probably the equivalents of the strata in the northern end of Whitecliff Bay, that contain an intermixture of marine and fluviatile shells.

Beyond Newtown Bay are Hampstead Cliffs (about three miles east of Yarmouth), consisting of calcareous marls, with the usual fluviatile shells in great abundance. In this locality, leaves of dicotyledonous plants ‡ occasionally occur; and Mr. Prestwich has recently discovered great numbers of an undescribed species of *Cypris*. The lower part of the cliff consists of sand containing freshwater with marine and estuary shells.

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* Mr. Webster mentions that the arenaceous limestone of which the castle is built was quarried near the spot. In these quarries, for ten or twelve feet below the surface, the strata consist of sand and imbedded waterworn blocks of limestone. Sir H. Englefield states that in the low cliff on the shore, the same species of shells as in the limestone occur as perfect as if fresh from the river or lake.

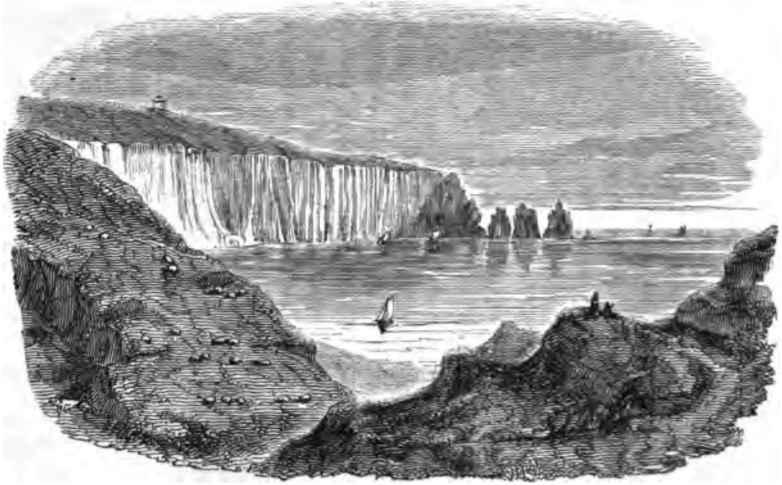
† Mr. Lyell states that the entire buckler with the bones of a tortoise was obtained from Thorness Bay. "Geol. Trans." vol. ii. p. 290.

‡ Similar to those found in the plastic clay at Newhaven, in Sussex, and figured in my "Fossils of the South Downs," Pl. I.

We next pass Yarmouth, and doubling the headland on which was Worsley's Tower, opposite Hurst Castle, enter Colwell Bay, where the cliffs exhibit alternations of marine and freshwater strata. In the fissure called *Bramble Chine* a thick bed of oyster-shells is exposed, apparently in its original state, the valves being in contact with each other as when living; this appears to be the equivalent of the oyster bed observable at Whitecliff Bay. Many beautiful fossil shells may be collected in this locality. The elegant *Cytherea incrassata* (Pl. III. fig. 6), and *Neritina concava* (Pl. II. fig. 5), are found in sandy clay, in as perfect a state as if but recently thrown up by the waves. In Totland, or Tolland's Bay, similar sands, clays, and marls form the cliffs.

HEADON HILL AND ALUM BAY.—We now approach Headon Hill and the richly-coloured vertical strata of Alum Bay. The picturesque character of the dislocated masses of strata forming the face of the cliffs at Headon Hill is shown in Pl. IX. The appearance of Alum Bay from the sea is imposing in the extreme, and is thus graphically described by Sir Henry Englefield:—"The scenery of this bay is very superior in magnificence to that of any other part of the island. The chalk forms an unbroken face everywhere nearly perpendicular, and in some parts formidably projecting, and the tenderest stains of ochreous yellow and greenish moist vegetation vary without breaking its sublime uniformity. This vast wall extends nearly a quarter of a mile, and is more than 400 feet in height; it terminates by a thin projection of a bold broken outline, and the wedge-shaped Needle Rocks rising out of the blue waters continue the cliff in idea beyond its present boundary, and give an awful impression of the stormy ages which have gradually devoured its enormous mass. The pearly

Pl. VIII.



ALUM BAY, FROM HEADON HILL; LOOKING SOUTHWARD.

hue of the chalk under certain conditions of the atmosphere and light is beyond description by words, and probably out of the power even of the pencil to portray.

"The magical repose of this side of the bay is wonderfully contrasted by the torn forms and vivid colouring of the clay cliffs on the opposite side. These do not, as at Whitecliff, present rounded headlands clothed with turf and shrubs, but offer a series of points of a scalloped form, and which are often sharp and pinnacled. Deep rugged chasms divide the strata in many places, and not a trace of vegetation appears in any part. All is wild ruin! The tints of the cliffs are so bright and so varied, that they have not the aspect of anything natural. Deep purplish red, dusky blue, bright ochreous yellow, grey, nearly approaching to white, and absolute black, succeed each other, as sharply defined as the stripes in silk; and after rains, the sun, which from about noon till his setting in summer illuminates them more and more, gives a brilliancy to some of these nearly as resplendent as the bright lights on real silk. Small vessels often lie in this bay for the purpose of loading chalk and sand, and they serve admirably to show the majestic size of the cliffs under whose shade they lie diminished almost to nothing."*

GEOLOGY OF ALUM BAY.—Although the unconformable position and dislocated state of the strata at Headon Hill appear, at first sight, to present but little correspondence with the nearly horizontal freshwater deposits at Whitecliff Bay, and the richly-coloured and variegated stripes of sands and clays of the vertical cliffs of Alum Bay, still less to resemble the dull ochreous marine beds exposed in the breaks of the turf-covered slopes of that locality—yet a careful examination will soon convince the observer, that the geological characters of this north-western section of the eocene strata, agree in every essential feature with those which engaged his attention at the eastern extremity of the Island.* The diagram, lign. 11, will serve to show the close analogy between the deposits of Whitecliff and of Alum Bay. This correspondence, and the extension of the same beds throughout the northern portion of the Isle of Wight, were ascertained and distinctly enunciated by Mr. Webster, in his admirable memoir on the "Strata above the Chalk."†

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* Sir H. Englefield's "Isle of Wight," p. 81.

From the incessant action of the sea on the base of Headon Hill, large masses of the upper beds are continually falling down; and the face of the cliff is generally in so ruinous a state, that the true stratigraphical position of the deposits is seldom visible. Repeated observations have, however, ascertained that the superior beds are nearly horizontal, but curve upwards as they approach the vertical strata, in the same manner as the corresponding layers at Whitecliff. In the sketch, Pl. IX., the upper masses of marl and limestone are lying in this position. The footpath that leads from Grove's Hotel, down the chasm by which Headon Hill is separated from Alum Bay, reaches the sea shore at the point marked *b*, in lign. 11, and which is indicated by the two upper figures in Pl. IX. The visitor, therefore, upon arriving on the strand, has the horizontal freshwater series on the north, and the vertical marine beds on the south, flanked by the lofty chalk cliffs of High-Down, and the Needles.

At Alum Bay, as at Whitecliff, the lacustrine and fluviatile deposits are the uppermost series (lign. 11, *a*);

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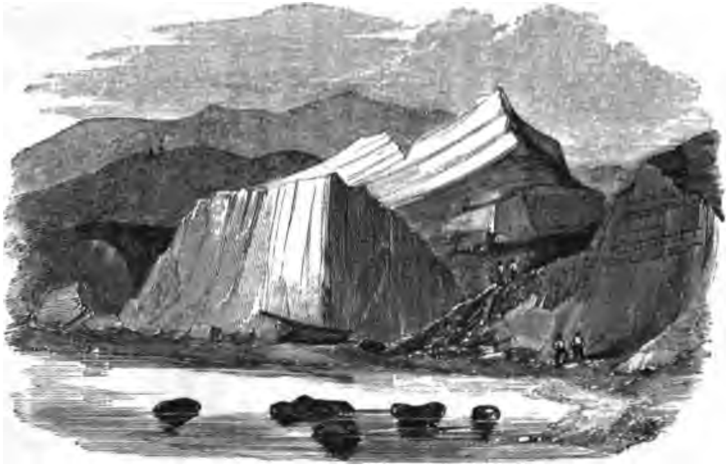
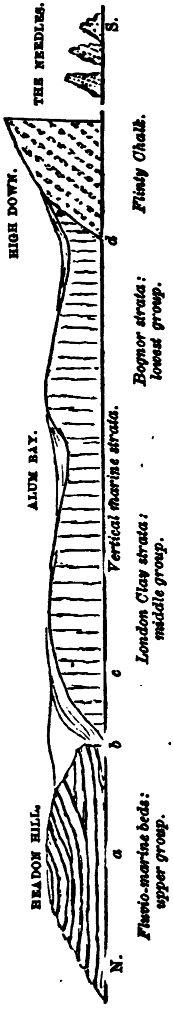
* Mr. Prestwich has given accurate and detailed sections of Alum Bay and Whitecliff, in juxta-position on the same plate, and thus admirably illustrated the relations of the strata in the two localities. "Geol. Journal," No. 7.

† On the "Freshwater Formations in the Isle of Wight," &c. "Geol. Trans." vol. ii. p. 161, first series; 1814.

Pl. IX.



VIEW OF THE STRATA AT HEADON HILL, FROM THE SHORE.



LIGN. 11.—DIAGRAM OF THE EOCENE STRATA AT ALUM BAY AND HEADON HILL.

the strata most decidedly marine, comprising the London clay, occupy a vertical position, and are the middle series (lign. 11, *c*); the group denominated the Bognor strata being the lowermost; then follow the mottled clays, and these abut against a bed of sandy loam, with pebbles and slightly rolled flints, that is in immediate contact with the chalk; as shown in lign. 11, *d*. The thickness of the eocene strata, from the chalk to the uppermost bed in Headon Hill, is stated by Mr. Prestwich to be 1,660 feet; which is 300 feet less than the series at Whitecliff.

The surface of the chalk in contact with the tertiary beds is much worn, and covered by a layer of sandy loam, containing pebbles and rolled flints, which are invested with a coating of green earth. Flints of this kind occur also at Newhaven, and in the fissures and sand-pipes of the Surrey and Sussex downs. Mottled clays and sand, with traces of lignite, as at Whitecliff, next appear, for a thickness of nearly 100 feet; and then the brown clay, with layers of septaria, abounding in the *ditrupa;* this is the lowermost bed of the Bognor * rocks. Beds of sandy clay with seams of pebbles, belonging to the same group, succeed, and in some of the layers marine shells are numerous. A fossil crab common at Sheppey (*Cancer Leachii*) was found in this clay by Mr. Bowerbank.

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* More than twenty species of shells, and some teeth of sharks, are enumerated

The variegated and deeply-tinted sands, marls, and clays, which impart so remarkable and brilliant an aspect to the cliff, are the next in order, and form a total thickness of between 700 and 800 feet. The alternations and variety of the vertical seams or layers are almost innumerable. The sands are of every shade of red, yellow, green, and grey; some are white, and others almost black: the clays are equally diversified. Mr. Webster remarks that "the variety of the vertical layers is endless, and may be compared to the vivid stripes of a parti-coloured tulip. On cutting down pieces of the cliff, it is astonishing to see the extreme brightness of the colours, and the delicacy and thinness of the several layers of white and red sand, shale and white sand, yellow clay and white and red sand; and indeed almost every imaginable combination of these materials. In the midst of this series there are vertical layers of pebbles, and one thick stratum and many seams of lignite. In some of the clays dicotyledonous leaves have been discovered, but no animal remains.

These richly-coloured strata are followed by clays with septaria, seams of pebbles, and a bed of green sand, the whole comprising a thickness of between 200 and 300 feet. In some of these deposits the usual London clay shells are abundant, especially near the spot marked *c* in

by Mr. Prestwich, from this group. The most characteristic are *Ditrupa plana*, *Pectunculus brevirostris*, *Turritella imbricataria*, *Pholadomya margaritacea*, *Panopæa intermedia*, and *Vermetus Bognorensis;* all well-known Bognor shells, and mentioned in the earliest list of the fossils of that locality. See my "Geology of the South-East of England."

lign. 11.[*] The dark sandy clay immediately on the north side of the chasm *b* is also very prolific, and I have collected from it numerous choice specimens. Nummulites, and other foraminifera, occur in some of the beds.[†]

We now arrive at the foot of Headon Hill; and here the lowermost stratum visible on the beach is a pure white sand, which is largely exported for the glass manufactories; this is covered by a bed of yellowish clay. A series of variously-coloured sands, marls, and clays, with layers of friable limestone succeed. The predominating fossils are species of the freshwater genera, *limneus, planorbis, melanopsis, potamides, cyrena,* &c., with which the reader is already familiar. But there are in some of the beds a few marine and estuary shells, as *cytherea, ancillaria, corbula,* &c.; and a layer of oyster shells occurs, similar to that already noticed in the cliff at Colwell Bay. Within fifty feet of the top of the hill there is a stratum of reddish brown and mottled clay with seams of lignite; and on this is superimposed whitish sand and marl, with interstratified layers of concretionary limestone, full of freshwater shells. A thick bed of gravel forms the alluvial covering on the summit of the hill.

GEOLOGICAL MUTATIONS.—From this sketch of the lithological characters and organic remains of the strata in this locality, it will be seen that the phenomena under review present a close analogy to those observable in Whitecliff Bay; the discrepancy being inconsiderable, and such as may have resulted from slight changes in the hydrographical condition of the district during the accumulation of the deposits. In both places there are proofs that the commencement of the eocene formation took place in a wide and open sea, the first accumulation of detritus on the water-worn surface of the chalk being an argillaceous sediment, in which no animal remains were imbedded. The earliest group of fossils, the Bognor series, comprises the shells of marine mollusks that do not inhabit deep sea-water, but live in depths averaging from ten to twenty fathoms. This depth, as Mr. Prestwich observes, would be obviously inadequate to allow of the accumulation of detritus sufficient to form strata which, when desiccated, are from 200 to 300 feet in thickness; and as the lithological character of the beds denotes a quiet and uniform deposit for a considerable time, and the fossils indicate an unaltered condition of animal life throughout the same period, a tranquil and gradual subsidence of the sea-bottom must have taken place. The many hundred feet of sedimentary strata which were superimposed on the Bognor series denote a subsequent subsidence to a great depth, to allow of the accumulation of the London clays and sands. This epoch was followed by a gradual transition to an estuarine and lacustrine condition, as shown by the layers of fluvio-marine and freshwater shells. But the freshwater lake or estuary was subjected to occasional irruptions of the sea; hence the beds of oysters, and interspersion of a few marine shells. A barrier was at length raised to the influx of sea-water, and the sediments became exclusively of a fluviatile and lacustrine character. This is proved by the prevalence of freshwater plants, crustaceans, and mollusks; and the presence of bones of terrestrial reptiles, and of mammalia.*

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[*] The two figures in the foreground, Pl. IX., are near this locality.

[†] See Mr. Prestwich's "Memoir," for lists of the characteristic fossils found in each stratum, throughout the entire series of deposits.

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* This interpretation of the phenomena is a concise expression of the generalisation of Mr. Prestwich, whose admirable "Memoir" should be carefully studied by those who would enter fully into all the bearings of this interesting inquiry. See "Journal of the Geological Society," No. 7.

Organic Remains.—Alum Bay and Headon Hill will afford the visitor an abundant supply of fossil shells in great perfection and variety. Figures of a few characteristic species are given in Pl. I. and II.

Potomomya gregaria,	Pl. II.	fig. 1	Headon Hill.
Potamides concavus	„	„ 2	„
„ plicatus	„	„ 8	„
„ ventricosus	„	„ 9	„
Planorbis euomphalus	Pl. I.	„ 1	„
Limneus fusiformis	„	„ 4	„
„ longiscatus	„	„ 3	„
Paludina angulosa	„	„ 6	„
Melanopsis fusiformis	Pl. II.	„ 3	„
„ brevis	„	„ 4	„
Psammobia solida	Pl. III.	„ 1	„
Cytherea incrassata	„	„ 6	„
Corbula cuspidata	„	„ 2	Alum Bay.
Ancillaria subulata	„	„ 4	„
Neritina concava	Pl. II.	„ 5	„
Ditrupa plana	Pl. III.	„ 3	„
Panopæa intermedia	„	„ 5	„
Cardita planicosta	„	„ 7	„

Teeth of two species of Palæotherium (*P. crassum* and *P. medium*,) were obtained by Mr. Prestwich from Headon Hill; and I have seen a block of limestone, in which were imbedded several ribs of a small mammalian, from the same locality.

A few species of crustaceans have been collected from the blue London clay, near the footpath. Gyrogonites, and impressions of dicotyledonous leaves, and lignite, are the only vegetable remains I have observed.

The fluvio-marine and freshwater shells may be collected in great numbers from the fallen masses of strata that lie on the sea-shore. In the marls, the shells of the limnei, planorbes, &c., are well preserved; a chisel will be required to extract them. Thousands of the small species of *potamides*, *melanopsis*, &c., will be found on the strand, having been washed out of the clays and sands composing the cliff. Very fine specimens of several species of marine shells may be obtained from the dark clay at the point marked *b*, in lign. 11. The spot which I have found most prolific is the base of the cliff at the commencement of the footpath, near the sea-shore.

YARMOUTH AND LYMINGTON.—It is unnecessary to extend our remarks on the eocene formations of the Island; from what has been advanced, the intelligent visitor will readily comprehend the geological phenomena observable in the localities not comprised in our excursions. But before entering upon the examination of the next system, the *Chalk*, we would recommend a brief sojourn at Yarmouth; which is a convenient location for the geologist to visit Totland and Colwell Bays, Hampstead Cliff, and a few places on the opposite coast of Hampshire, which have long been celebrated for their organic remains.

The town of Lymington is situated on the western bank of the river of the same name, about four miles from Yarmouth, across the Solent Sea; to this place there are steam-packets from the Island several times in the day. The town is spread over a low hill of tertiary strata. Near the brick-kilns on the eastern bank of the river, not far from the toll-gate, a deep excavation has been made in beds of sand and clay, containing fossils.* An alluvial layer of gravel, ten feet deep, lies upon laminated blue and greenish clays, with interspersions of lignite, four feet in thickness. The next stratum is fine white sand, like that of Headon Hill and Hordwell Cliff, six feet; and beneath is blue (London?) clay, to an uncertain depth. In this clay I found several vertebræ and dermal bones of a crocodile, (*Crocodilus Spenceri*,†) and a few fragments of bones of turtles. I observed no vestiges of shells, but learnt from the workmen that several kinds were occasionally found, and also many bones, but none had been preserved.*

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* This section was open in 1845.

† A well-known species of the London clay at Sheppey.

CHRISTCHURCH BAY.—Christchurch Bay is a semi-elliptical excavation, about eleven miles long, formed by the action of the sea on the Hampshire coast, which is here composed of an extension of the eocene strata of the north-west part of the Isle of Wight; the two portions being now separated by the British Channel, which flows into the Solent Sea. The westernmost point of the bay is Hengistbury Head, near Christchurch; the easternmost is the bar of shingle on which Hurst Castle is situated. Along the line of coast bounding the bay, there are several places in which sections both of the marine and freshwater strata are exposed; and Hordle, or Hordwell Cliff, near the little village of that name, has long been known as an inexhaustible mine of fossil relics. So long since as 1766, a quarto work was published in illustration of the organic remains of this locality, with engravings, which, for accuracy and artistic skill, far surpass most of the modern figures of objects of this kind.†

Hordwell is about midway between Lymington and Christchurch; but from Yarmouth, in fine weather, a boat offers the most convenient transport. Hurst Castle, which guards the narrow part of the Solent Strait, here not a mile across, is built on the extremity of a bar of shingle, that extends nearly two miles from the mainland, on the eastern part of Christchurch Bay. This bank consists of waterworn chalk-flints, and gravel derived from the alluvial drift, which is so largely distributed over the coast district. "It is remarkable," as Sir Henry Englefield observes, "for its uncommon solidity; for it is merely a submarine cliff of shingle, 200 feet high, the depth of the channel close to the castle being 33 fathoms; and the tide flows through it with a rapidity which, at certain times, no boat can stem; yet this natural breakwater has remained unmoved for centuries."*

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* This brief notice is inserted to direct attention to a locality hitherto, I believe, unexplored. I recommended the workmen to save every shell, bone, and tooth, they might meet with. Some future visitor will, perhaps, reap the benefit of the suggestion.

† "Fossilia Hantoniensia collecta et in Musæo Britannico deposita, a Gustavo Brander, Londini, 1766." "Hampshire Fossils," &c. with nine plates, containing 131 figures.

At the junction of the bar of Hurst Castle with the mainland, a low bank of gravel extends for about a quarter of a mile, and is succeeded by tertiary sands and clays, which gradually rise into cliffs 200 feet high; the first mile and a half being Hordwell Cliff, properly so called, which reaches to Long-mead End. From this spot to a ravine formed by a stream at Beacon Bunny, a distance of half a mile, the cliff is named Beacon Cliff. The next two miles and a quarter is Barton Cliff, which is terminated by a stream at Cherton Bunny; and the remainder of the line to near Muddiford, is High Cliff.† The alluvial gravel which forms the subsoil of so large a portion of this coast, appears at the top of the cliffs in a bed varying from twenty to fifty feet in thickness.‡

STRATA OF HORDWELL CLIFF.—The eocene strata in the coast sections have in no instance a vertical, or even highly inclined position, but gently dip to the east. The Headon Hill series first appears, and constitutes the Hordwell Cliff; and the London clays and sands which rise to the surface at Barton Cliff, form the remaining portion of this line of coast. The strata of Hordwell Cliff consist of alternating beds of marl, sand, and clay, often of a greenish colour, with thin bands of indurated shell-marl full of the usual freshwater species. Mr. Searles Wood mentions that a thin seam of sandy clay, abounding in marine shells, is intercalated with these lacustrine strata a few paces westward of a ravine that is situated half a mile from the village of Milford. It is about ten or twelve feet above high-water mark, and extends many yards along the cliff.* The freshwater beds continue as far as Beacon Bunny, and in the upper part of that ravine, beneath the alluvial gravel, there is a bed of fluvio-marine sand, containing an intermixture of estuary and fluviatile shells, which may be traced to the eastward under the freshwater marl, to about 300 yards from Mead-end, where it disappears beneath the shingle of the beach.† This is succeeded by a fine white siliceous sand, like that at the base of Headon Hill, forming a stratum from 60 to 100 feet thick. The London clay series next appears, and extends through Barton and High Cliffs. The upper portion of the beds consists of sandy clay of a dark green colour, like that at the base of the cliff in Alum Bay (marked *b* in lign. 11), and abounds in marine shells; beneath are layers of septaria.

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* See Sir H. Englefield's "Isle of Wight," p. 14, for many interesting remarks on the bed of the Solent.

† These localities are accurately described by Mr. Webster, in his second "Memoir," and are here introduced that the visitor may have no difficulty in finding the places hereafter mentioned as yielding certain species of organic remains.

‡ The stratification of the coast, from the west of Christchurch to the chalk at Studland Bay, in Dorsetshire, a distance of seventeen miles, is described by Mr. Lyell, in "Geol. Trans.," vol. ii. p. 279.

The strata at Hordwell Cliff are regarded by Mr. Lyell as the equivalents of the lacustrine beds which form the coast from Yarmouth to Gurnet Point, where the strata lose the character of an indurated calcareous marl, and are not unfrequently of a bright green colour, like many of the layers of marl and clay at Hordwell. Detailed descriptions of the strata and their fossils are given by this eminent geologist in the second volume of the "Geolog. Trans;" the following summary will be useful to the visitor:—

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* The new "London Journal of Palæontology and Geology," p. 2.

† Mr. Searles Wood *loc. cit.*

1. Alluvial gravel, forming the top of the cliff; composed of broken chalk-flints, with interspersions of sand and marl; thickness from 5 to 50 feet.
2. Fine white sand with greenish marl;—from 3 to 12 feet.
3. Green marls, with arenaceous clays;—16 feet. Contain bituminous wood and seed-vessels, with shells of the genera helix, unio, melanopsis, planorbis, and other lacustrine species. The lowest stratum is laminated marl, with layers of *Cyprides*.
4. Sands and clays;—15 feet. Numerous shells of the *mya gregaria*. Lignite occurs in a layer of bituminous clay.
5. White calcareous marl, largely constituted of aggregated freshwater shells; contains gyrogonites (see p. 78). It rests on a layer of black carbonaceous clay, with lignite; 1 foot.
6. Green unctuous and arenaceous marls; the lower portion consists of beds of pure white sand, with argillaceous sands;—15 feet. Numerous fluviatile shells. The white sand contains abundance of the shells of a small mussel (*mya plana*) in a very perfect state.
7. Light-green calcareous and sandy marls, with layers of a carbonaceous clay containing lignite;—22 feet. Numerous shells, and seed-vessels.
8. Green marl, carbonaceous clay and lignite, ferruginous clay, marl *with vegetable impressions*, and green clay;—9 feet. Freshwater shells, principally two or three species of bivalves.
9. White siliceous sand, without shells; rises near Long-mead End, and extends through Beacon and Barton Cliffs to the middle of High Cliff.*

Near Bournemouth, a little watering-place on the Hampshire coast, between Hengistbury Head and Poole Harbour, dicotyledonous leaves, in a carbonised state, of the same species of plants as those found in Alum Bay (*ante*, p. 117), occur in a sandy marl, which traverses a cliff of firmly aggregated white sand.* I am informed by William Smart, Esq., of Cranbourne (to whom I am indebted for many interesting specimens of these fossil leaves), that the seam of marl is only four inches in thickness, and is limited to a few yards of the cliff, near the base; it is about midway between Bournemouth and Boscombe Chine.

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* "On the Freshwater Strata of Hordwell, Beacon, and Barton Cliffs, Hampshire," by Charles Lyell, Esq. "Geol. Trans." vol. ii. p. 287, Second Series.

In addition to the fossils previously discovered, Mr. Searles Wood has recently obtained the remains of five genera of mammalia and of one alligator, consisting of a jaw with all the teeth, of lizards, serpents, and birds. The following remarks on the geological phenomena observable at Hordwell Cliff are too pertinent to be omitted:—"From the examination of the various strata which are exhibited in the beautiful section of Barton and Hordwell Cliffs, and of their peculiar fossils, one may follow in imagination the gradual silting up of an estuary, and its passage eastward into a pure river deposit. Leaving the regular beds of London clay, which dip gradually to the eastward, and are lost in the beach below Beacon Bunny and Long-mead End, we meet with a stratum of sand in which marine and freshwater shells are intermixed, and one of clay containing leaves and seeds, with an extensive layer of lignite. Upon this is a bed whose organic contents display a still nearer approach to freshwater origin by the absence of the more decidedly marine genera, as *oliva*, *natica*, &c., and the presence of *cyrena*, *potomomya*, &c., in great abundance. Next comes a layer of brown sand, containing rolled fragments of bones of *palæotherium*, *trionyx*, &c., which, from their appearance, may have been transported from a considerable distance. Over this rests a deposit of marl and white sand (No. 6 in Mr. Lyell's section), the latter in the state of an impalpable powder; in this were deposited nearly all the fossils above-mentioned. The strata incline to the east at an angle of about 5°. The direction of the stream was no doubt westerly—that is, toward the marine beds; but at the spot at which I obtained so many interesting fossils there were indications of a contrary current; a circumstance, however, which may very probably have depended upon a sudden bend in the river. The uniformly fine character of the sand, and the condition in which it was thrown down, would lead me to infer that the flow of the stream was extremely gentle. The gradual disappearance of marine species, such as are found at Longmead End, and their replacement, as we proceed eastward, by species of freshwater origin, is just such a succession as we should expect to meet in tracing the course of a river upwards from its mouth."*

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* "Medals of Creation," vol. i. p. 193.

HORDWELL FOSSILS.—The numerous marine fossil shells which are obtained from this part of the coast of Hampshire are generally known as Hordwell fossils, but it is scarcely necessary to remark, that they almost entirely belong to the London clay strata, and are procured from Barton Cliffs. These fossils are most conveniently obtained from the low cliff near Beacon Bunny, and occur in greatest abundance in the upper part of the dark green sandy clay. There are generally blocks of the indurated portions of the strata on the beach, from which fossils may be extracted. It was from Barton Cliff that Brander's fossils† were obtained. Sowerby's "Mineral Conchology" contains figures of numerous species and genera.‡

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* The new "London Geological and Palæontological Journal," *loc. cit.*

† Fossilia Hantoniensia.

‡ A collection of Hordwell fossils, consisting of teeth of several species of sharks and rays, bones of turtles, and a great variety of shells, may be purchased at a reasonable price of Jane Webber, dealer in fossils, Barton Cliff, near Christchurch.

The freshwater shells, and the remains of plants and land animals, are to be looked for in Hordwell Cliff, and in the fallen masses lying on the strand.*

In conclusion, it may be remarked that shells of those beautiful chambered cephalopoda, the *nautili*, are seldom, if ever, observed in the eocene strata of these cliffs, or in those of the Island; though the *nautilus imperialis* is not uncommon in the septaria on the western coast of Sussex, and in the London clay at Sheppey.

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* The highly interesting specimens which have rewarded the recent investigations of Mr. Searles Wood will doubtless induce many a collector to visit the spot. The lower jaw of the *Alligator Hantoniensis*, a coloured plate of which embellishes the first number of the new "London Geological Journal," is one of the most splendid British fossils hitherto discovered. Plate 2 of the same work contains figures of some of the mammalian remains discovered at Hordwell by Mr. S. Wood.

CHAPTER VI.

THE CHALK FORMATION — SUBDIVISIONS OF THE CRETACEOUS SYSTEM—RANGE OF THE CHALK IN THE ISLE OF WIGHT—THE UPPER AND LOWER CHALK—CHALK AND FLINT—SILICIFIED FOSSILS OF THE CHALK—THE FIRESTONE—THE GALT—THE GREENSAND—SUMMARY.

THE CHALK FORMATION.—The different members of the *Cretaceous system,* though presenting considerable variety of lithological character, are yet essentially of the same type, and are linked together by a peculiar fauna, indicating the prevalence of a similar oceanic condition throughout the vast period of time comprised in this geological epoch.

The features of a chalk district are so well known, that a brief notice of the physical geography of that part of the Island which is composed of the cretaceous strata, will suffice for our present purpose; and a reference to the map, Pl. XX., will render local details unnecessary. The rounded summits of the hills covered with short verdant turf—the smooth undulated outline of the downs unbroken save by the sepulchral mounds of the early inhabitants of the country—the coombes and furrows ramifying and extending into the deep valleys which abruptly terminate at the base of the hills, and appear like dried up channels of rivulets and streams, though free from all traces of alluvial debris—thus bearing the impress of physical operations of which the agents that produced them have long since passed away—are phenomena familiar to every one who has travelled over the downs of the south-east of England, and are displayed in striking characters in the chalk districts of the "beautiful Island." These features are restricted to the hilly districts of the *white chalk*, and have resulted from the peculiar nature of the sedimentary detritus of which the strata comprised in the upper division of the cretaceous system are composed. For in the lower groups clays, marls, sands, and sandstones prevail; and where these deposits approach the surface and form the subsoil, the country is broken and diversified, and the landscape presents a striking contrast with the down scenery, as may be observed in the picturesque district which flanks the escarpment of the chalk hills.

It may perhaps be necessary to remind the unscientific observer that these strata are but an insulated portion of an ancient sea-bottom, or, in other words, a mass of consolidated sediments formed in the profound depths of the ocean, in a very remote period of the earth's physical history. This detritus is made up of inorganic and organic materials: the former consist of the debris of the cliffs and shores which encompassed the ancient sea; of the spoils of islands and continents brought into the ocean by freshwater currents; and of chemical deposits thrown down from mineral solutions. The organic substances are the durable remains of animals and plants which lived and died in the ocean, and of fluviatile and terrestrial species that were transported from the land by rivers and their tributaries; the whole forming such an assemblage of sedimentary deposits as would probably be presented to observation, if a mass of the bed of the Atlantic 2,000 feet in thickness were elevated above the waters, and became dry land.

SUBDIVISIONS OF THE CRETACEOUS SYSTEM.—The nomenclature of the chalk formation has undergone so many alterations that, to avoid confusion, it is necessary to define the precise meaning which the terms employed in the following pages are intended to convey.

Chalk formation and *Cretaceous system* are synonymous terms, and designate the entire series of deposits between the Wealden and the lowermost eocene stratum.

THE CHALK—signifies the *white* chalk, including 1, the *upper* or *flinty* chalk; and 2, the lower or hard chalk, in which but few, if any, flints occur.

THE FIRESTONE OR GLAUCONITE—comprises the *chalk-marl*, without any intermixture of green particles, as well as the limestone called in Sussex *malm-rock;* and the sands and arenaceous marls and limestones full of green particles of silicate of iron, and termed by geologists the *upper greensand* and *firestone.* This group is the *Glauconie crayeuse* of the French geologists.

THE GALT—a deposit of stiff blue clay underlying the firestone, and characterised by particular species of organic remains: called also *Folkstone marl,* and *Blue chalk marl.*

THE GREENSAND—designates the series of clays, sands, sandstones, and arenaceous limestones; comprising the *Iron-sand* of Mr. Webster, the *Lower greensand* of Dr. Fitton (and of the map Pl. XX.), the *Shanklin sands* of the author, and the lower argillaceous group, termed the *Neocomian* or *Atherfield* deposits.

RANGE OF THE CHALK FORMATION IN THE ISLAND.—The various members of the cretaceous system, as previously stated, constitute the southern half of the Island, a range of chalk hills, broken through by the transverse valley of the Medina, extending from east to west, and separating the northern and southern districts. At Sandown Bay we have seen the lower divisions of the formation successively appearing in the cliffs, in the anticlinal axis formed by the elevation of the Wealden strata; and in Compton Bay, a like elevation of these deposits in a similar anticlinal system.

At Culver Cliff, and from High Down to Compton Bay, the chalk downs, consisting of highly inclined strata, form the sea boundary; but in the middle of the island this chain is flanked on the south by a denuded district of the lower strata, which expands several miles, and is succeeded by another system of downs formed of horizontal beds of chalk. This range extends from St. Catherine's to Shanklin Down, a distance of six miles. (See the Map and Section, Pl. XX.) Thus, in travelling from the northern part of the Island to the southern shore—as, for example, from Ryde to Sandown, or from Calbourne to Brixton—vertical and highly-inclined strata of the flinty chalk are first passed over, and then the firestone, galt, and greensand deposits; the latter composing the sea-cliffs from Sandown to Atherfield, except where the fallen masses of the upper beds strewn along the Undercliff conceal them from observation. But in crossing the central district the chalk range is first traversed, and on the southern flank of the hills the firestone, galt, and greensand appear, and the latter extend southward several miles, and dip beneath another chain of hills capped with white chalk strata; and on the south of this second range the firestone, galt, and greensand again emerge, and contribute to form the picturesque region of the Undercliff.

The Upper and Lower Chalk.—In pursuing this inquiry I propose, before conducting the reader to the most interesting localities, to explain more fully the inorganic and organic composition of the principal deposits of the chalk formation; and thus afford a general view of the mineral characters and organic remains of the strata that will come under review in our excursions along the southern coast.

The superior group of the cretaceous system consists of white limestone disposed in strata, which vary in thickness from a few inches to several feet. In the Upper Chalk there are numerous parallel rows of siliceous nodules that occur at irregular distances from each other; and in some places there are sheets of flint (called *tabular* flint) between the layers of chalk, which extend over considerable areas. The cretaceous strata are also traversed by vertical and diagonal veins of the same substance. In the Lower Chalk of England flints are of very rare occurrence, and in general are altogether absent. The greatest total thickness of the white chalk strata is estimated at 1,000 feet. The only metallic substances observable are oxide of manganese in the state of dendriditical or arborescent markings in the chalk and flints, and sulphurets and oxides of iron. The most common form is the sulphuret of iron, or pyrites, in spherical nodules beset with crystals, which radiate from the centre, and, when broken, a shell or other foreign substance is very commonly found to be the nucleus. This substance often forms the casts of echinites, terebratulæ, and other shells, the surface of the mineral retaining sharp imprints of the original. The bones and scales of fishes and other animals imbedded in chalk have invariably a ferruginous stain.

CHALK AND FLINT.—The pure white chalk is composed of lime and carbonic acid; it dissolves rapidly in hydrochloric acid, and leaves only a slight residuum, consisting of silex and organic matter. A microscopical analysis shows it to be a mere aggregation of shells and corals, so minute that upwards of a million are contained in a cubic inch of chalk; the amorphous particles appear to be the detritus of similar structures. These organisms, for the most part, are the calcareous shields and chambered shells of the animalcules termed *foraminifera*, which swarm in inconceivable numbers in our present seas, and are daily and hourly contributing to the amount of sediment now forming in the bed of the ocean.*

The nodules and veins of flint that are so abundant in the upper chalk, have probably been produced by the agency of heated waters and vapours. The perfect fluidity of the siliceous matter before its consolidation, is proved not only by the sharp moulds and impressions of shells, &c., retained by the flints, but also by the presence of numerous organic bodies in the substance of the nodular masses, and the silicified condition of the sponges and other zoophytes which swarm in some of the cretaceous strata.

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* See "Medals of Creation," article, "Fossil Animalcules," p. 215.

Although silex or the earth of flint is insoluble in water of the ordinary temperature, its solution readily takes place in vapour heated a little above that of fused cast-iron, as has been proved by direct experiment;* and similar effects are being produced at the present moment by natural causes. The siliceous deposits formed by the intermittent boiling fountains, called the *geysers*, in Iceland, are well known;† and in New Zealand this phenomenon is exhibited on a still grander scale. From the crater of the volcanic mountain of Tongariro, which has an elevation of 6,200 feet above the level of the sea, jets of vapour and streams of boiling water highly charged with silex are continually issuing forth, and, dashing down the flanks of the volcano in cascades and torrents, empty themselves into the lakes at its base. As the temperature of the water diminishes, siliceous sinter is deposited in vast sheets, and incrustations of flint are thrown down on the extraneous substances lying in the course of these thermal streams. Silex is also precipitated by the boiling waters in the state of stalagmitic concretions, and *in nodules resembling in colour and solidity the flints of the English chalk.*‡ The complete impregnation and silicification (*i.e.* transmutation into flint) of organic bodies is referable to an agency of this kind, as the eminent American mineralogist, Mr. Dana, has clearly shown.*

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* An account of Mr. Jefferey's important experiments will be found in the "Reports of the British Association" for 1840.

† "Wonders of Geology," vol. i. p. 84.

‡ Dr. Dieffenbach's "New Zealand."

SILICIFIED FOSSILS OF THE CHALK.—In many instances the organic remains in chalk flints are simply incrusted by silex. Such is the state of numerous sponges which are as it were invested by the flint, and have their pores and tubes filled by the same material, the original tissue appearing as a brown earth. In other examples the sponge has been enveloped by a mass of liquid silex, and has subsesequently perished. In this manner have been formed those hollow nodules, which on being broken present a cavity containing only a little white powder, or some fragments of silicified sponge, while in other instances the cavity is lined with quartz or chalcedony. It frequently happens that part of the zoophyte only is permeated by silex, while the other portion is a friable calcareous substance imbedded in the chalk. Certain zoophytes (*Ventriculites*, see "Medals of Creation," vol. i. p. 274,) are often found in this state; hence the protean forms of the flints that have been moulded on portions of these organisms.

But there are innumerable flint nodules which exhibit no traces of spongeous structure; and veins, dykes, and sheets of tabular flint that may be regarded as pure, and free from organic remains, excepting such as must inevitably have become entangled and imbedded in a stream of mineral matter flowing over a sea-bottom.

A sponge or other organic body often forms the nucleus of the flint nodules, and the original substance of the fossil is generally transformed into silex, and yet the most delicate structure preserved. In other examples the organisms enclosed in the flint have undergone no change, but appear as if immersed and preserved in a semi-transparent medium. Such is the state in which the foraminiferous shells (*rotaliæ, textilariæ,* "Medals of Creation," p. 232,) and minute corals often occur.*

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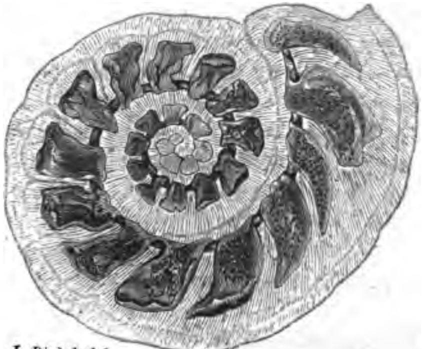
* "American Journal of Science," for January, 1845. See also, "Notes of a Microscopical Examination of Chalk and Flint," by the Author. "Annals Nat. Hist." 1845.

Fossil Animalcules.—For the most part the microscopic shells in chalk and flint are filled with amorphous mineral matter; but recent observations have shown that in numerous examples the shell contains the *body* of the animal, in some instances silicified, but in others *in the state of a dried animal substance,* like the ink-bag of the



J. Dinkel, del.

LIGN. 12.—THE SHELL OF A ROTALIA;
Containing the fossilised remains of the body of the animal; in flint;
highly magnified.†

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* An exquisite example of this kind was discovered by the Marquis of Northampton in a chalk flint from Brighton. In a polished slice of this specimen, presented to me by his lordship, there are branches of several delicate corals (*pustulopora, retepora, idmonea*—"Medals," p. 284) and foraminifera, as perfect and unaltered in appearance as if immersed in glass.

† Specimens of the Rotaliæ, Xanthidia, and other minute fossil organisms of the chalk and flint may be obtained of Mr. Topping, the well-known microscopic artist, No. 1, York Place, Pentonville Hill, London. See "Medals of Creation," vol. i. pp. 78, 244, for instructions how to prepare fossils for the microscope.

cuttle-fish in lias,* the soft parts of cephalopoda in clay,† and the capsule of the eye and the membranes of the stomach of certain fishes, in chalk.‡ In flint such specimens are by no means rare, and, from the semi-transparency of that mineral, are easily detected. The annexed figure (lign. 12) represents the body of a rotalia in its shell (highly magnified) imbedded in an atom of flint, in which there is another example, and some other organisms. The shells of *rotaliæ* in the chalk also contain the body of the animal; and by dissolving the chalk and the shell in weak hydrochloric acid, and immersing the residue in a transparent medium (Canada balsam), the soft parts are as distinctly seen as in a recent dead specimen.§

So little attention has been paid to the white chalk fossils of the Island, that a few of the common species of *terebratula, spondylus,* and *echini;* teeth of sharks; *ventriculites, choanites,* and other zoöphytes, comprise almost all the specimens I have observed in private collections; but there can be no doubt that were the quarries and natural sections diligently examined, an interesting series might be obtained. ||

THE FIRESTONE.¶—The lower white chalk, in some

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* Dr. Buckland, "Bridgewater Treatise."

† Professor Owen on the Belemnite.

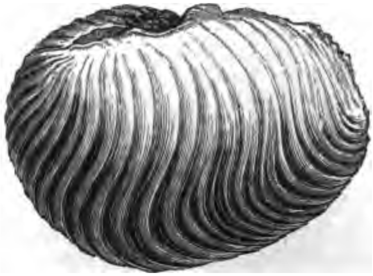
‡ "Wonders of Geology."

§ A memoir on this subject, by the author, will be found in the third part of the "Philosophical Transactions for 1846."

|| Figures and descriptions of British chalk fossils are given in my "Fossils of the South Downs," "Wonders of Geology," and "Medals of Creation," and "Geology of the South-East of England;" in Sowerby's "Mineral Conchology," Mr. Lyell's "Elements of Geology," and in Parkinson's "Organic Remains of a Former World."

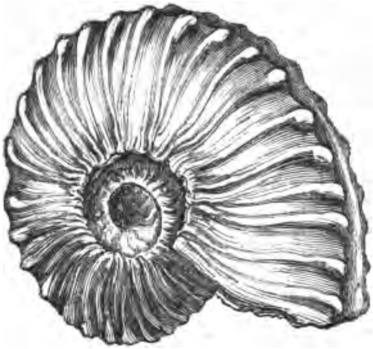
¶ The name Upper Greensand, generally given to these arenaceous marl beds of the chalk formation, has been productive of so much confusion that the provincial term, Firestone, however inapplicable as a descriptive term, seems preferable.

places, as at Dover, gradually passes down into a bluish-grey chalk, and the latter into an argillaceous limestone, well known by the name of chalk-marl. In other localities the chalk maintains its purity to its junction with the marl. An intermixture of greensand characterises the latter in many districts, and this variety passes into a hard calcareous sandstone, termed in Surrey Firestone. Deposits of green, sand, with layers and concretions of chert, and seams and nodules of coarse chalcedony, characterise this group in some districts, and are largely developed in the Undercliff. The bands of siliceous limestones and calcareous sandstones, with veins and nodules of chert which appear in the inland cliff of that district, belong to this division of the cretaceous system.

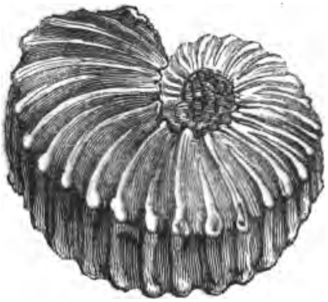


LIGN. 13.—NAUTILUS ELEGANS.
From the Chalk-marl, near Ventnor.

The chalk-marl in most localities abounds in fossils; it contains numerous species of ammonites, nautilus, turrilites, and other cephalopoda, which are either of excessive rarity, or altogether absent in the upper chalk strata. The nautilus and ammonites figured in the subjoined lignographs, 13, 14, 15, are characteristic species of the chalk-marl. The specimen of *Nautilus elegans*, lign. 13, is a young shell: this species is often two feet in circumference.



LIGN. 14—AMMONITES VARIANS.
From the Chalk-marl, near Bonchurch.



LIGN. 15.—AMMONITES MANTELLI.
From the Chalk-marl, near Bonchurch.

Some localities of the Island are extremely prolific in organic remains, and have yielded to the researches of Capt. Ibbetson an interesting series.* J. M. Saxby, Esq., of Bellevue House, has recently collected many species from

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* There is a good suite of marl fossils belonging to this gentleman exhibited in the Isle of Wight model-room of the Polytechnic Institution of London.

Bonchurch and Ventnor. A list of the fossils obtained by Dr. Fitton from these strata, chiefly from the cliff at Western Lines, is given in "Geol. Trans." vol. iv. p. 202.

THE GALT.—This is a deposit of very dark blue marl, having an average thickness of 100 feet; the clay in many places has a large intermixture of greensand, and is traversed by thin layers of red marl. It presents no distinctive mineral aspect, but is characterised by the abundance, peculiarity, and state of preservation of its fossils. Numerous species of ammonites, hamites, and other cephalopoda, with their nacreous shells entire, and bivalves and gasteropodous univalves, seldom if ever found in the strata above or below, may be collected from most localities where the galt is exposed in natural or artificial sections of any considerable extent. This deposit is seen on each side of the anticlinals on the southern coast, and in some parts of the Undercliff, near Ventnor and Bonchurch; I believe only a few fossils have been observed.

THE GREENSAND.—This division of the cretaceous system comprises numerous alternations of argillaceous and arenaceous strata of great thickness and extent, constituting an important group, which is well defined by the fossil remains.

It consists of cherty and calcareous sandstones, and sands of various colours, white, green, grey, red, brown, fawn, yellow, and ferruginous: the predominance of the green sands in some districts having suggested the term now employed to designate the group. It was called the ironsand where the ferruginous character predominated, as in the Isle of Wight.* Thick beds of sandy and ferruginous clay, are intercalated with the arenaceous strata. The greensand is separable into three divisions, as was first shown by Dr. Fitton, whose indefatigable and successful labours have so largely contributed to the elucidation of the characters and relations of the deposits between the chalk and oolite in England.

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* The whole series is described by Mr. Webster as the ironsand, in his various memoirs on the geology of the Isle of Wight; and the unfortunate application of this term to the sands of the Wealden districts of Surrey, Kent, and Sussex, retarded, for a long period, the true exposition of the nature and relation of those deposits.

In the upper or Shanklin sand series, the strata are chiefly ferruginous sands with ironstone and concretions of chert, with dark clays in the lower part. The middle group is marked by the prevalence of green and grey sand with beds of calcareous sandstones, and cherty limestone, called Bargate-stone in Surrey, and Rag in Kent. In the lowermost or Atherfield series the argillaceous character predominates. The beds of sand abound in peculiar fossils, and the concretionary limestones and sandstones contain characteristic organic remains. This general notice will suffice, as the details of the sections exposed along the southern coast of the Island have been worked out by Mr. Webster, Dr. Fitton, Captain Ibbetson, Professor Forbes, and other eminent observers, and are published in the Transactions and Journal of the Geological Society.

The following species of shells from the Greensand of the Isle of Wight, are figured in Plates IV. and V:—

Corbis corrugata, Pl. IV. fig. 1. This and the following figure represent but one side of the bivalves, and therefore do not convey an idea of the form of the entire shell; but the markings on the surface are distinctly given, as affording the easiest comparison for the inexperienced collector.

Trigonia caudata, Pl. IV. fig. 2. This shell is so remarkable both in its form and sculpture, as to be easily identified.

Gervillia anceps, Pl. IV. fig. 3. Entire beds of this shell occur in some of the sands at Atherfield. The species is generally more elongated than in the individual figured.

Venus striato-costata, Pl. IV. fig. 4. A small and easily recognised shell.

Venus parva, Pl. IV. fig. 7. In ironstone nodules in Shanklin cliff.

Arca raulini, Pl. IV. fig. 5.

Perna mulleti. Pl. IV. fig. 6. This large and remarkable bivalve occurs in great numbers in a thick layer immediately above the junction of the greensand with the Wealden, at Atherfield and Sandown-bay. The prolonged hinge line is commonly broken off in extracting the shells from their matrix, unless due care is taken.

Thetis minor, Pl. V. figs. 1, 2. These are only casts in ironstone, the shell having perished. They are abundant in the concretions from the ferruginous sand on the top of the cliff at Dunnose Point, that have fallen on the shore.

Gryphea sinuata, Pl. V. fig. 3. This shell attains a large size; specimens are numerous along the shores at Shanklin, Ventnor, and in Compton-bay; being washed out of the cliffs of greensand.

Terebratula sella, Pl. V. fig. 5. This shell in a very perfect state is found by hundreds in the greensand at Atherfield, &c. It occurs in great numbers in the greensand-pits at Faringdon, in Berkshire.

Nucula scapha, Pl. V. fig. 6. This and the following small shells abound in the Atherfield Crackers-rock.

Tornatella albensis, Pl. V. fig. 4.

Natica rotundata, Pl. V. fig. 7.

Pterocera retusa, Pl. V. fig. 8.

Rostellaria robaldina, Pl. V. fig. 9.

Cerithium turriculatum, Pl. V. fig. 10.

Scaphites gigas, Pl. V. fig. 11. This shell attains a large size; specimens two feet long are sometimes found. The collections of Capt. Ibbetson and Mr. Bowerbank contain splendid examples. Imperfect specimens of the spiral part have been described under different generic names.

Summary.—The character of the cretaceous system, as shown by these investigations, is that of an ocean-bed formed in a vast basin by successive accumulations of sedimentary detritus, transported by currents, and thrown down in the tranquil depths of the sea; arenaceous and argillaceous deposits prevailing in the lower, and cretaceous in the upper division of the series; periodical intrusions of heated fluids charged with silex having taken place at uncertain intervals. The fossils prove that the ocean swarmed with innumerable beings of the usual orders of vertebrate and invertebrate marine organisms, belonging for the most part to species and genera now unknown; and in the chalk are seen for the last time that numerous tribe of cephalopoda, the ammonites, of which not a single species is known either in the tertiary strata or in any more recent deposits: so far as our knowledge at present extends, with the chalk the whole race of ammonites disappeared.

With regard to the vegetable kingdom of the cretaceous period, the presence of numerous fuci attests the nature of the marine flora; and the fragments of drifted coniferous wood, fir-cones, stems and leaves, which are found in the flint and chalk in some localities, prove that the dry land was clothed with pine-forests, and cycadeous plants. The occasional discovery of bones and teeth of reptiles, shows that the islands and continents were tenanted by oviparous quadrupeds.* Of birds and mammalia not a vestige has been discovered.

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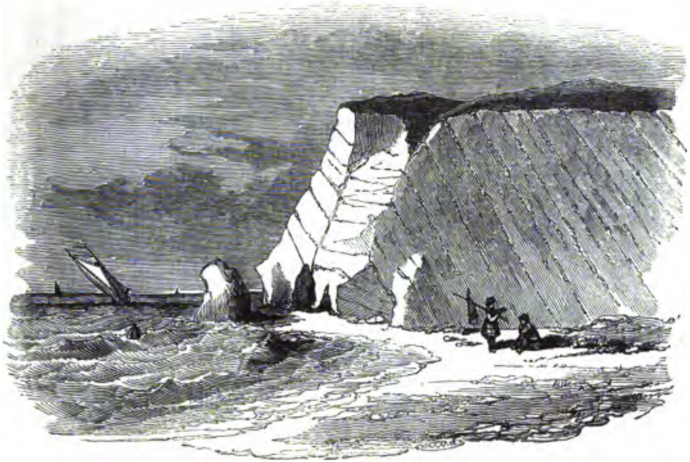
* It is worthy of remark, that fossils and fragments of other rocks are very rarely found in the white chalk. Pebbles of quartz and sandstone are the only extraneous minerals of frequent occurrence. A solitary instance of fragments of green chlorite schist, in chalk marl, near Lewes, was discovered by myself some twenty-five years ago. My friend, Henry Carr, Esq., C.E., recently found some water-worn pieces of fossil-wood imbedded in white chalk, from the cutting of the railway between Epsom and Croydon. This wood, in its mineralogical character and organic structure, is unquestionably identical with the well-known fossil-wood of the Portland oolite, and I have no doubt is a portion of a mass that was drifted into the bed of the cretaceous ocean.

Pl. X.



CHALK CLIFFS NEAR FRESHWATER-GATE; LOOKING WESTWARD.

CHAPTER VII.

FROM YARMOUTH TO FRESHWATER-GATE—SCRATCHELL'S BAY—VERTICAL CHALK STRATA—SHATTERED FLINTS—THE CHALK DOWNS—CAUSES OF THE PRESENT CONFIGURATION OF THE CHALK HILLS—FROM FRESHWATER-GATE TO COMPTON BAY—GEOLOGICAL SECTIONS OF THE SOUTHERN COAST—PEBBLES AND SHINGLE.

FROM YARMOUTH TO FRESHWATER-GATE.—In resuming our survey of the geological phenomena of the Isle of Wight, we proceed from Yarmouth to Freshwater-gate, on the south-western shore. In a direct line, through the transverse valley of the river Yar, which rises from the northern foot of the downs, the distance but little exceeds two miles and a half; but the road makes a considerable detour to the left, round the eastern border of the estuary. Passing over a gently undulated country of the fluvio-marine eocene strata, and ascending a steep acclivity of tertiary sands, we cross the narrow tract of highly-inclined chalk which unites Afton-Downs on the east with High Down on the west, and reach the southern coast by an opening in the chalk cliffs that extend from Compton Bay to the Needles.

Immediately on our left are some detached pinnacles of chalk jutting into the sea, and on the right the fine section of highly-inclined strata of chalk and flint represented in Pl. X. At the base of this headland is the entrance to a considerable excavation in the cliff, produced by the erosive action of the waves on the lower beds of chalk; some perpendicular masses of the harder portions of the rock worn into irregular columns support this natural archway, which is known to tourists as "The Cave." It extends 120 feet into the cliff, and is between thirty and forty feet high;* it is well deserving the notice of the geologist, for the displacement the strata have undergone is here strikingly displayed.

From Freshwater-gate to the Needles, a distance of three miles, the cliffs present a succession of mural precipices of chalk from 400 to upwards of 600 feet in height. The face of these cliffs when seen from the sea at a short distance has a remarkable appearance, from the rows o flints, which score the surface of the white rock with fine dark parallel lines, running in an oblique direction from the top to the bottom of the section. In some places the lines are undulated, in others arched, and near the summit of the cliff towards Alum Bay, they are very flexuous, and bent down, as if a heavy mass above had pressed upon the upper ends of the layers of flints, while the chalk was in a plastic state. The general inclination of the beds of this part of the range is nearly vertical on the north, with a gradually decreasing angle towards the south.

SCRATCHELL'S BAY.—The most stupendous line of chalk cliffs is that termed the Main-bench; and beyond is Scratchell's Bay, which is bounded by the Needles. The aspect of the scene in this bay is romantic in the extreme. In the face of the cliff, from the destruction of the lower beds of the bent strata, a magnificent arch 300 feet high has been produced, and forms an alcove that overhangs the beach 150 feet.†

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* The description and beautiful illustrations of the picturesque features of the scenery along this part of the coast, in Sir H. Englefield's "Isle of Wight," render it unnecessary to dwell upon this inviting subject. Some of Mr. Bartlett's views of these chalk cliffs, in Barber's "Illustrations," are very accurate and effective.

† In calm weather Scratchell's Bay and the Needles may be safely visited in the pleasure-boats to be hired at Freshwater Gate; parties generally land on this strip of shingle to view the stupendous arch above. A splendid view of the bay, by Mr. Webster is given in Pl. 25, of Sir H. Englefield's work.

The well-known pinnacles of chalk called The Needles are isolated masses of the extreme western point of the middle range of Downs, which have been produced by the decomposition and wearing away of the rock in the direction of the joints or fissures, with which the strata are traversed. The angular or wedge-shaped form of these rocks, has resulted from the highly inclined northward dip of the beds of which they are composed.

VERTICAL CHALK STRATA.—To the late Sir Henry Englefield belongs the merit of having first observed and directed attention to the highly interesting phenomena, occasioned by the disruption and elevation of the eocene and cretaceous formations, which are so remarkably displayed in the Isle of Wight—namely, the vertical position of the strata, and the shattered condition of the flint nodules, though still imbedded in the solid rock. These appearances may be conveniently examined in the cliffs before us.

The chalk forms parallel beds or strata varying from two to five feet in thickness, which are commonly separated by layers of flint nodules imbedded at irregular distances from each other; there are also a few nodules dispersed indiscriminately in the mass. The dip of the inclined strata as previously stated is in general from 70° to 80°: but many beds throughout a considerable extent are quite vertical. (See Pl. XIII.) The parallelism of the cretaceous strata, and the absence of sand, gravel, and other coarse detritus, denote that the deposition of these calcareous sediments took place in tranquil water, and remote from sea-cliffs and shores. Where a large extent of the cliff is exposed, the face of the chalk is seen to be traversed by *fissures* or *joints* at right angles to the planes of stratification; some are vertical, others diagonal, and crossing in various directions, divide the entire mass into irregular portions; in some localities these partake of a rhomboidal form.* These fissures have evidently been produced after the consolidation of the strata in which they occur, for where they traverse the horizontal layers of flint nodules, some of the latter are often displaced; and very commonly a fault, or interruption of the parallelism of the opposite sides of the chasm, has taken place, either from the elevation or the subsidence of one of the separated masses. In many instances the fissures are filled up with flint, which occupies the crevice wholly, or partially, throughout its whole extent, forming large sheets of pure silex, varying in thickness from that of pasteboard to two or three inches. These siliceous veins often consist of two plates with loose calcareous detritus between them, as if the flint had flowed down or oozed from the sides of the fissures; and this detritus is frequently composed of shells of microscopic foraminifera. In other cases the cavities are filled with marly and soft chalk; and in many instances they are empty, but their sides are lined with crystallised carbonate of lime. These fissures are evidently referrable to a period long antecedent to the elevatory movements which broke up the chalk strata, and hurled them into their present position, for they traverse the horizontal layers; and the subsequent introduction of flint, proves that they were the effect of submarine movements, which took place while the physical condition of the bed of the cretaceous ocean remained unchanged. This fact also corroborates the inference, that the eruptions of steam or vapour charged with silex into the chalk, occurred periodically, and sometimes at long intervals.

But there are numerous chasms and fissures in the strata which clearly belong to a very different epoch; to a period geologically recent, when the now upper surface of the chalk was rent by earthquakes, and the mountain masses of the cretaceous system acquired their present position and configuration. For these fissures are invariably connected with the surface, and are more or less filled with clay, sand, gravel, and waterworn flints, from the alluvial debris that forms the subsoil of the country. These appearances may be observed in the chalk underlying the bed of gravel and clay, on which the Albion Hotel at Freshwater-gate is situated.

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* Mr. Webster particularises the large chalk-pit on the south side of Arreton Down near the top, not far from Ryde. In this quarry the strata are inclined at an angle of 80 deg.; and both the tabular flints and the nodules are completely shivered.

SHATTERED FLINTS.—Upon carefully extracting a flint nodule from this cliff it retains its original form; but upon examination it will be found "shattered in every direction and broken into pieces, varying in size from three inches in diameter down to the minutest fragment, and even into an impalpable powder. The flints thus shivered, as if by a blow of inconceivable force, retain their form and position in the bed. The chalk closely invests them on every side, and till removed, nothing different from other flints can be perceived, excepting fine lines indicating the fracture, as in broken glass; but when moved, they fall at once to pieces. The fragments are as sharp as possible, and quite irregular, being certainly not the effect of any peculiar crystallisation or internal arrangement of the material, but solely attributable to external violence." Such is the description of this remarkable phenomenon given by Sir H. Englefield thirty years since.* The tabular and plated flint in the fissures is also shattered in a similar manner. The nodules in the regular layers are invariably in this state, in every locality of the vertical and highly inclined chalk; but the separate nodules in the middle of the strata are entire; and in the horizontal beds, as, for example, on St. Catherine's, Boniface, and Shanklin Downs, all the flints are unbroken. This shattered condition of the flints has doubtless arisen, as Sir Henry Englefield suggested, from the concussion caused by the upheaval and disruption of the once horizontal cretaceous deposits. The disturbing force, though in many instances producing flexures in the strata, was clearly exerted violently and suddenly, and in such manner as to shatter the flints without dislodging them from the chalk. From the insulated nodules being generally entire, it would seem that the greatest violence of the shock was exerted in the direction of the lines of stratification.

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* Sir H. Englefield's "Isle of Wight," pp. 20, 21. The following places are enumerated as exhibiting this phenomenon very distinctly:—Alum Bay, Pit south of Carisbrook Castle, and near Carisbrook town, Arreton Pit, Brading-Down Pit, Brading Shute, Culver Cliff. Shattered flints are occasionally met with in some parts of the Sussex and Surrey chalk. My attention was first directed to the subject in 1820, by a paper of Sir H. Englefield, in the "Linnæan Transactions;" and a chalk-pit on the top of North Street, Brighton, now filled up, and the area built over, presented

Mr. Webster, in describing the shivered flints in the chalk at Handfast Point, on the Dorsetshire coast, remarks that the nodules are not only much shattered, but appear as if they had been reduced to atoms while the rock was yet *in a soft state*, for the fragments are in general separated from each other, with chalk between them; and the broken pieces of flint are at such distances, that it is impossible to conceive by what means they could have been so far separated, had the chalk been solid at the moment of their fracture. The bent condition of the strata at Handfast Point, which will be described in a future page, attests the plastic state of the chalk at the period when its upheaval took place.

THE CHALK DOWNS.—We now leave the sea-shore to ascend the hill, and proceed along the foot of Afton Down to Compton Bay, which is about a mile distant. The

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a fine example, for every flint, though retaining its form, was reduced to fragments. See the "Fossils of the South Downs," page 152.

western part of the central range of downs extends from the Needles Cliff to Motteston Down, which is 700 feet high, and is a narrow ridge nine miles in length, with steep declivities on each side; that on the north arises from the highly-inclined dip of the strata; that on the south is produced by the precipitous escarpment formed by the sudden termination of the cretaceous beds where they rise to the surface. The summits of this range command views of great extent and picturesque beauty, for both the northern and southern shores are distinctly visible.* From the Needles Down may be seen on the north Tollands, Colwell, and Yarmouth bays; and on the south, Freshwater and Compton bays, and the distant line of coast. The eastern portion of this chalk range, from Arreton Down to Culver Cliff, a distance of seven miles, is of the same character.†

* A graphic description of the scenery from this range of hills is given by Sir H. Englefield, chap. iii. The view from Buccomb Down, looking over Carisbrook Castle and Newport in the vale beneath, is very splendid; that from Arreton Down is equally fine.

† The view from Ashey sea-mark, which is situated on this part of the chalk-hills between Arreton and Brading Down, is thus described by the Rev. Legh Richmond:—

"Southward the view is terminated by a long range of hills (Shanklin, Wroxall, and Appuldurcombe), at about six miles distant. They meet to the westward another chain of hills, of which the one whereon I sit forms a link, and the whole together nearly encompass a rich and fruitful valley, filled with corn-fields and pastures. Through this vale winds a small stream for many miles; here and there lesser eminences arise in the valley, some covered with wood, others with corn or grass, and a few with heath or fern. One of these hills is distinguished by a church (New Church) at the top, presenting a striking feature in the landscape. Villages, churches, country-seats, farm-houses, and cottages are scattered over part of the southern valley. In this direction also appears an ancient mansion (Knighton), embellished with woods, groves, and gardens. South-eastward is a broad expanse of ocean, bounded only by the horizon. More to the

Ascending Afton Down, the summit of which is crowned with a group of tumuli, the views along the southern coast are lovely in the extreme. When almost half way up the acclivity, the landscape to the west displays a magnificent *coup d'œil* of the romantic scenery of Freshwater and Scratchell's Bays, and the Needles; and that to the east affords a view of Compton Bay, Brook Bay, and the coast, till it is lost in the remote distance.

CAUSE OF THE CONFIGURATION OF CHALK DOWNS.—From what has been stated as to the composition of the white chalk, and the formation of the strata, the cause of the external configuration of the verdant downs we are now traversing appears sufficiently obvious. If we examine the spots where the turf has been removed by the flint-diggers, we perceive immediately beneath the vegetable mould a thick layer of loose nodules but slightly abraded, and in no instance worn into the state of boulders, pebbles,

east, in continuation of the chain of hills on which I am sitting (Ashey), rise two downs (Brading and Yaverland hills), one beyond the other; both are covered with sheep, and the sea is just visible over the furthest hill, as a terminating boundary. In this point are seen ships, some of which are sailing, and others lying at anchor. On the north, the sea appears like a noble river (the Solent), varying from three to seven miles in breadth, between the banks of the opposite coast and those of the island. Immediately underneath me is a fine woody district, diversified by many pleasing objects. Distant towns (Portsmouth and Gosport) are visible on the opposite coast; and numbers of ships occupy the sheltered station which this northern channel affords them. Westward, the hills follow each other, forming several intermediate and partial valleys, in undulations like the waves of the sea, and bending to the south, complete the boundary of the larger valley I have described, to the southward of the hill on which I sit. One hill alone (St. Catherine's), the highest in elevation, and about ten miles to the south-westward, is enveloped in a cloud, which just permits a dim and hazy sight of a signal-post, a light-house, and an ancient chantry, on its summit."—*Annals of the Poor, by the late Rev. Legh Richmond.*

or gravel. The surface of the chalk covered by the flints is furrowed and waterworn, like that of the exposed chalk along the coast. From the state of the loose flints it is evident that, although they must have been washed out of pre-existing strata, they have not been subjected to the action of the waves for any considerable period, like the materials of the existing sea-beach. For when masses of the chalk cliffs fall within reach of the billows, the exposed portions of the flints are completely rounded before the nodules are loosened and detached from the parent rock; and so soon as the flints are liberated by the wearing away of the surrounding chalk, they are quickly driven against each other and broken, and the fragments ground into pebbles, gravel, &c. In this manner are formed the shingle and sands that accumulate along the sea-shore.

From the state of the down-flints, it is therefore obvious that the deposits whence they were derived must have been less consolidated than the present chalk, and have admitted of the removal of the calcareous materials, and the consequent extrication of the siliceous nodules from the rock, in a comparatively short space of time; and the disengaged flints, after a very brief exposure to attrition, must have been transported beyond the reach of the waves.

From the organic composition of the chalk (*ante*, p. 130), it is manifest that when first deposited at the bottom of the ocean, it was a fine white detritus or mud, resembling in its nature and appearance the chalk now in progress of formation along the coasts of the Bermuda islands;* some layers of which are as rich in microscopic shells as any of the cretaceous strata. The veins and beds of flint, as we have previously explained, probably originated from the periodical introduction of thermal waters highly charged with silica into the calcareous sediment. The subsequent conversion of the incoherent detritus into compact limestone may have resulted in part from pressure, but principally from the slow infiltration of crystalline carbonate of lime; a process which has so rapidly converted the mud of the Bermudas into a rock fit for building, that the imbedded shells, in many instances, retain their natural colour and polish.

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* "Wonders of Geology," vol. i. p. 69.

It may, therefore, with great probability, be assumed, that at the period when the cretaceous strata were subjected to those elevatory movements which ultimately raised enormous mountain-masses of chalk, together with the Wealden deposits on which they rest, above the level of the sea, the last-formed, uppermost, and, of course, least coherent beds, would be the first exposed to the action of the waves; and if the elevation were gradual,* successive layers would be subjected to the same agency, until the fragments of the ancient ocean-bed, now the Downs, were lifted above the reach of further destruction. The drainings of the elevated portions of the soft calcareous rock would then commence, and give rise to streams and rills, by which the surface would be worn into furrows and channels. Funnel-like cavities, and deep and narrow cylindrical and tubular hollows, would be formed by the gyratory action of eddies or whirlpools, induced by opposing currents. Such effects may be observed on the muddy dunes of an estuary during the recession of the tide. The beds of loose and but slightly water-worn flints—the undulated and unbroken contour of the gently-swelling hills—and the smooth basin-shaped coombes and valleys of chalk districts—characters which are strikingly exemplified in the hills before us, would be the natural result of such operations.

FROM FRESHWATER GATE TO COMPTON BAY.—The road to Compton Bay sweeps round the southern slope of

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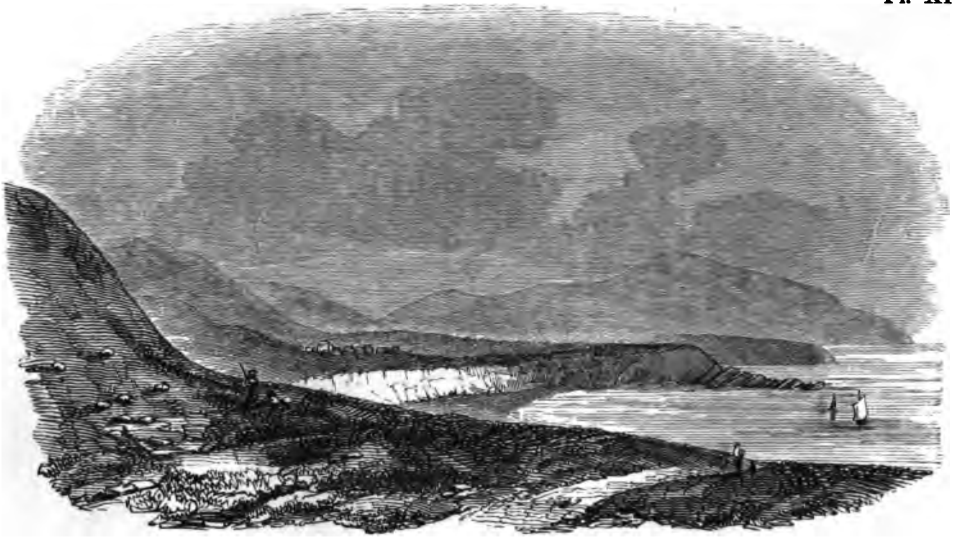
* See Mr. Lyell, on the elevation and denudation of the Wealden districts. "Elements of Geology," vol. ii.

Pl. XI,



COMPTON BAY AND BROOK POINT, FROM THE FOOT OF AFTON DOWN.

Afton Down. The pedestrian should take the path along the edge of the cliff to Compton Chine, where a narrow track leads to the sea-shore. As we approach this spot, a fine view is obtained of the line of coast from the bay to beyond Brook Point, as is shown in the slight sketch, Pl. XI. The foreground is part of the southern slope of Afton Down, consisting of flinty chalk; and the foot-track to the Chine is seen crossing it on the right. The cliffs in this view are composed of the clays, shales, and sands of the Wealden, which continue to near Atherfield Point. The nearest headland is Brook Point, the western boundary of Brook Bay; and the one immediately beyond is the eastern limit of the same. The ledges of rock, extending from the foot of Brook Point into the sea, are chiefly composed of petrified trees. The most distant cape is part of the greensand cliffs, near Blackgang Chine; and the lofty range on the horizon is St. Catherine's Hill.

Compton Chine is a deep chasm worn in the ferruginous sands by a stream that falls from the summit of the cliff. It is situated to the west of the Blockade-station.

The footpath to the shore slopes along the face of the crumbling cliffs of greensand strata, which rise from beneath the upper divisions of the cretaceous system, as is shown in lign. 16. The succession of the beds from Freshwater to Compton Bay, *i. e.*, from west to east, is as follows:—

1. Upper or flinty chalk.
2. Lower chalk.
3. Firestone, comprising the chalk marl.
4. Galt.
5. Greensand, consisting of beds of ferruginous sands, clays, sandstones, and layers of very compact ironstone grit.
6. Wealden clays, sands, shales, and limestones.

GEOLOGICAL SECTIONS OF THE SOUTHERN COAST.— The strata incline to the west, as is shown in lign. 16, to beyond Brook Chine, where the eastern side of the anticlinal axis begins, and the dip is to the east, as represented in the continuation of the coast in lign. 17.

This line of cliffs is, in fact, the counterpart of that of Sandown Bay (*ante*, p. 96, lign. 9); but the Wealden deposits are here more developed, and extend between six and seven miles along the shore. As these cliffs consist of clays, sandy marls, shales, and other materials that offer but feeble resistance to the action of the waves, the destruction effected by the sea during the winter and early spring, when the highest tides prevail, is very great; and the Wealden fossils washed out of the cliffs and strewn along these shores are so numerous, that the strand between Compton Bay and Atherfield has yielded a greater number of fossil bones of colossal reptiles than any other part of the Island. In short, these strata and their organic remains impart to this portion of the southern shore so much interest, that it is desirable to postpone a particular account of the Wealden deposits for a special excursion to Brook Bay. We will therefore continue our survey of the greensand by proceeding from Compton to Atherfield, and along the Undercliff to Sandown Bay, where our investigation of the south coast commenced.*

The chalk, firestone, and galt of Compton Bay are not very prolific in fossil remains; but the greensand yields *ammonites*, *trigoniæ*, *pernæ*, &c.; and numerous specimens of the large oyster-like *gryphea sinuata* (Pl. V. fig. 3) are generally scattered on the sands and shingle at the foot of the cliffs. At the point where the lowermost bed of the greensand is in contact with the Wealden clays, the distinctive characters of the marine and freshwater deposits may sometimes be observed in a mass of the stratum but a few inches thick; marine shells appearing

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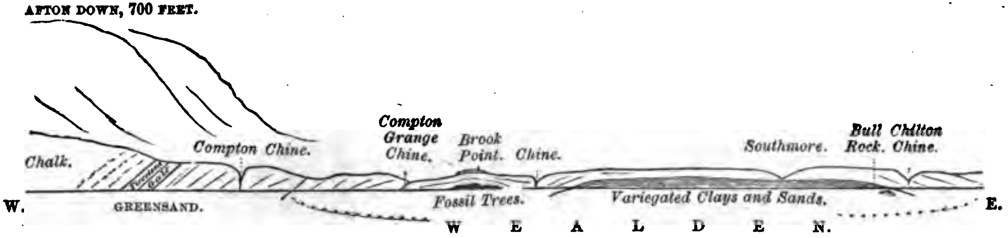
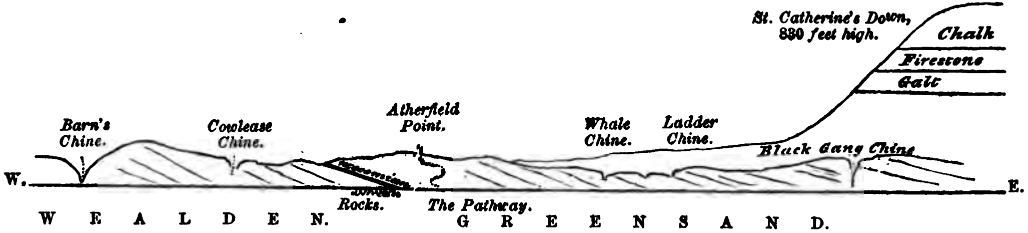
* The visitor who would find it more convenient to continue his observations along the cliff to Brook Chine, should refer to chapter ix.



LIGN. 16.—THE SECTION OF THE STRATA EXPOSED ON THE SOUTH COAST, FROM THE FOOT OF AFTON DOWN TO GRANGE CHINE.

(The distance about 4½ miles.)



LIGN. 17.—CONTINUATION OF THE COAST SECTION FROM GRANGE CHINE TO ST. CATHERINE'S DOWN.

The distance about 5 miles.

(*From Dr. Fitton's Memoir Geol. Trans.* vol. iv. pl. x^{a}.)

imbedded in the upper layers, and freshwater shells in the lower portion.

PEBBLES AND SHINGLE.—Before we ascend the cliff to pursue our excursion towards Atherfield, I would offer a few remarks on the sea-beach.

The beds of shingle along this coast consist, in a great measure, of chalk flints that have been broken and rounded by attrition into boulders, pebbles, and gravel. This is evident from the peculiar aspect and fracture of the stones, and the nature of their organic remains, of which some traces are generally manifest. The clear, transparent pebbles, with bands and veins of quartz and chalcedony, which in some specimens are as clear as crystal, and in others of a bright yellow, amber, dark brown, and bluish-black colour, have a similar origin. The moss-agates,* as they are called by the lapidaries, are silicified chalk sponges; and the beautiful fossils (*Choanites*) † commonly known as *petrified sea-anemones*, are characteristic zoophytes of the white chalk. Small pebbles of pure transparent quartz or rock-crystal are often found in the shingle in Compton and Sandown: these have probably been washed out of the Wealden strata, for pebbles identical in mineralogical character occur in the grits of Tilgate Forest and Tunbridge Wells.

But the shingle contains other siliceous pebbles which essentially differ from those of the chalk-flints. Some of these are composed of a dark-brown mottled jasper, and when cut and polished resemble the well-known Egyptian pebbles; others are of an opaque white jasper, veined with black dendritical or arborescent figures, or marked with zones of rich brown tints. Some have a concentric arrangement of bands of silex of various shades of colour, and resemble agates; others assume the character of botroidal and mammillated chalcedony.

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* Not the *German* moss-agates exhibited in the shops as the genuine productions of the Island. See note to page 2.

† "Thoughts on a Pebble," pl. 1 and 2.

The differences observable in the materials composing the shingle, did not escape the notice of Mr. Webster, who describes some of the principal varieties of the pebbles, and suggests that those which are not waterworn chalk-flints may have been derived from veins or nodular masses of silex, in tertiary strata now destroyed. A polished slice of silicified wood found in the shingle of Sandown Bay, was presented to me by Mr. Fowlstone, of Ryde.

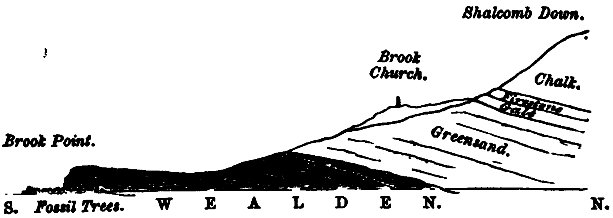
I believe specimens of this kind are very rare in the Island; but on the western coast of Sussex waterworn fragments of silicified monocotyledonous wood are occasionally met with.

Boulders and pebbles of petrified bone and wood, and of shelly limestone, are common on the beach in Compton and Sandown Bays; they are from the Wealden beds, and will be more particularly noticed in a subsequent chapter.

CHAPTER VIII.

FROM COMPTON BAY TO ATHERFIELD POINT—ATHERFIELD CLIFFS—GREENSAND SERIES—NEOCOMIAN OR ATHERFIELD STRATA—GREENSAND FOSSILS—CLIFFS AT BLACKGANG CHINE — THE UNDERCLIFF—GEOLOGICAL STRUCTURE OF THE UNDERCLIFF—FOSSILS OF THE FIRESTONE—SOUTHERN RANGE OF CHALK DOWNS—COAST OF THE UNDERCLIFF—FROM VENTNOR TO SANDOWN BAY.

From Compton Bay to Atherfield Point.—The road from Compton Chine to the coast-guard station at Atherfield Point runs along the southern flank of Shalcomb and Mottestone Downs. As we pass Brook Manor-house the ferruginous beds of greensand may be traced in the banks on the road-side; and Brook church is seen standing high up the hill on a terrace of those deposits. The relative positions of the strata in this district are displayed in the cuttings on the sides of the road from Shalcomb Down through the village of Brook to the sea-shore; as shown in lign. 18. If we proceed from the coast at Brook Chine through the village, and ascend the road by the church, and



LIGN. 18.—SECTION FROM BROOK-POINT TO SHALCOMB-DOWN; 1½ MILE.

over Shalcomb Down, we pass in succession, 1, the Wealden; 2, the Greensand; 3, the Galt; 4, the Firestone; and then cross the ridge formed by the highly-inclined strata of the White-chalk.

The turnpike-road leads through the villages of Mottestone* and Brixton to Shorwell, where it divides, and sends off a branch to Newport on the north-east, and another on the south-east, through Kingston and Chale to Blackgang Chine. About midway between Brixton and Shorwell a tenantry road turns off to the right, and admits a carriage to within a few hundred yards of the cliff, near the Atherfield coast-guard station. This is the most convenient place to alight, and reach the sea-shore near the junction of the greensand and Wealden formations. The path down the precipitous face of the cliff lies a little to the east of the station; it is a mere foot-track worn in the rock by the sailors and fishermen.† At a moderate distance westward of the spot where the path reaches the shore, is the headland called Atherfield Point, on which stands the station-house; and at its foot a ledge of rocks extends into the sea. Near this place, after recent slips of the cliff, and the removal of the fallen debris by the waves, the uppermost of the wealden deposits, and the lowermost of the greensand may be seen in juxta-position; in other words, the line of demarcation between the accumulated sediments of a mighty river—some primeval Nile or Ganges, teeming with the spoils of the land and the exuviæ of extinct terrestrial and fluviatile animals and plants—and the bed of a vast ocean, loaded with the debris of marine organisms, of genera and species unknown in the present seas.

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* On an eminence overlooking the village of Mottestone is a rude pillar of ferruginous sandstone called the "Long-stone," and which was probably erected as a landmark or boundary stone, at a very remote period. It is twelve feet high, and of an irregular quadrangular form.

† This path is too precipitous and inconvenient to be attempted without risk by ladies or invalids. I have always visited the spot by this route, and am not aware of there being a more easy descent to the beach, except at a long distance from the most interesting part of the cliffs.

ATHERFIELD CLIFFS.—These cliffs are about 150 feet high, and, with the exception of a few feet of Wealden clay forming the base of the headland above mentioned, entirely consist of the greensand strata, which extend eastward as far as the eye can reach. The total thickness of the series is upwards of 800 feet; but the section exposed, though vertical, is in an oblique direction to the planes of stratification, and from the slight angle at which the strata dip to the north-east, the cliffs as far as Blackgang Chine are composed of the greensand deposits. To the eastward these strata are concealed by the upper cretaceous group along the Undercliff, reappear at Bonchurch Cove, and continue to Sandown, extending as far as the anticlinal axis of the Wealden in the bay.

The lowermost bed which rests on the wealden at the base of Atherfield Point, is but a few feet above the beach; the uppermost strata first appear on the shore to the east of Rocken-end; between these two points the cliffs are made up of sands and argillaceous deposits of various colours, composition, and thickness, containing particular collocations of organic remains. The importance of the Atherfield section as elucidating the nature and relations of the lower group of the cretaceous system, was but little regarded till the appearance of Dr. Fitton's memoir "On the Strata between the Chalk and Oolite."* Since that time this locality has acquired additional interest from its affording a solution of the geological problem, to which we shall hereafter briefly advert. The subsequent memoirs by the same author,† Captain Ibbetson, Professor Edward Forbes,‡ and Mr. Simms,* contain an elaborate account of these deposits, and of the nature and distribution of the fossils they contain. The limits necessarily assigned to the present volume will only admit of a concise notice of the facts detailed in those publications, and a general view of the geological phenomena presented to observation in a stroll along the shore, from Atherfield Point to Blackgang Chine.

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* "Geol. Trans." vol. iv. 1836.

† "Geol. Journal," vol. i. p. 179.

‡ Ibid. p. 190.

GREENSAND SERIES.—There are 63 distinct beds between the Wealden at Atherfield Point, and the upper stratum of greensand which is in contact with the galt near Blackgang Chine; the total thickness being 843 feet.† These deposits have been variously grouped and named by different observers; but the most practically useful arrangement to the investigator on the spot is that which especially relates to the organic remains.‡ We will now briefly notice the principal subdivisions in an ascending order—that is, from the Wealden at Atherfield Point to the junction of the greensand with the galt (lign. 17).

The Wealden clay, as previously stated, first appears in a bed five or six feet thick, at the foot of Atherfield Point; the upper layers are shaley, and contain freshwater shells (*cyclas, paludina, potamides,*§ Pl. VI.) similar to those we observed at Sandown Bay.‖ The Wealden clay in the upper part is intermixed with grey and green sand; and two or three inches above there is a stratum of sandy clay containing marine shells. The distance between the layers of fluviatile and marine shells is therefore but a few inches; so that, as Dr. Fitton remarks, portable masses containing characteristic shells of both formations may be extracted. I have not been so fortunate as to visit Atherfield Point when the line of junction at the base of the cliff, and to the westward, was exposed to any considerable extent. But sometimes, from a conjunction of favourable circumstances, the strata are laid bare for several hundred yards. This happens after heavy gales and high tides, which sweep away both the fallen masses of rock and the sea-beach, and expose a large surface of the adjacent strata washed clean, and visible at low water.*

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* "Geol. Journal," p. 76.

† Captain Ibbetson.

‡ A list of the strata and a table of the distribution of the fossils are given in "Geol. Journal," vol. i. p. 195.

§ *Potamides* are spiral freshwater shells, which much resemble in form those belonging to a marine genus termed *Cerithium*. The *Cerithia* mentioned by Dr. Fitton as occurring in the Weald clay at Atherfield, may possibly be *Potamides*. I have never observed any vestiges of *Cerithia* in the Wealden deposits.

‖ A few small thin-shelled oysters were observed by Dr. Fitton in this bed. "These fossils occur within a very few inches from the junction with the sand above the Wealden."—"Proceedings, Geol. Soc."

1. *Lowest Greensand Clay.*†—A bed of brown clay with marine shells; three feet thick. In the lowermost layers, near the Wealden shale and clay, are seams of minute fish-bones.
2. *Perna Mulleti Band.*—A stratum two feet thick, of a very firm sand-rock, characterised by numerous shells, and especially by a layer of the *Perna mulleti* (Pl. IV. fig. 6), which also occurs in the same relative stratigraphical position in Compton and Sandown Bays.
3. *Lower Lobster Clay-bed.*—Clay strata, with numerous fossils in the lower, and but few in the middle beds. The upper layers are remarkable for the abundance of a small species of lobster (*Astacus*), which occurs in a beautiful state of perfection, imbedded in blue saponaceous clay approaching to fuller's earth. The specimen figured in the vignette of the title-page of this work is from this stratum. Total thickness 100 feet.
4. *The Cracker's Rock.*‡—Sandy clay, with two bands of nodular

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* Such was the state of the cliff when visited by Dr. Fitton in 1843. "Proc. Geol. Soc." vol. iv. part 1.

† The names adopted are those employed by Captain Ibbetson and Professor E. Forbes. "Geol. Journal," vol. i. p. 190.

‡ This local name is said to be derived from the noise made by the breakers when dashing over the rocks and ledges of this concretionary sand-rock.

or concretionary masses of very hard calciferous sandstone; eighteen feet. These beds are highly interesting for the abundance and variety of their organic remains. The nodules consist of very compact rock, and contain innumerable shells in a perfect state, of which many species do not occur in any other strata. The *Gervillia anceps* (Pl. IV. fig. 3) is crowded together in groups of hundreds, and the shells are as perfect as if lying in their native bed. Several small shells from the Cracker's rock are figured in Pl. V. (figs. 4, 6, 7, 8, 9, 10). These fossils occur in such numbers and variety, that almost every considerable fragment of the rock will be found to contain several species.

5. *Upper Lobster Clay.*—A deposit of saponaceous clay, similar to No. 3, and abounding in the same kind of fossil lobsters as that bed. It also contains ammonites and other shells; total thickness twenty feet.
6. *Zone of Terebratulæ.*—Clays full of fossils, twenty feet; above which is a bed of dark sand, twenty-two feet in thickness, enclosing immense numbers of *Terebratulæ* (Pl. V. fig. 5), and *Serpulæ*.
7. *Zones of Gryphea and Scaphites.*—A series of sands and clays, including layers of *Gryphea* (the large bivalve figured in Pl. V. fig. 3), imbedded in dark sand, and alternating with bands of nodules which contain gigantic *Scaphites* (Pl. V. fig. 11), ammonites, and numerous other fossils; total thickness, 155 feet.
8. *Upper zone of Terebratulæ.*—A bed of sand, thirty feet thick, full of layers of Terebratulæ (chiefly of *Terebratula biplicata*); above which is a stratum of dark sand, twenty-four feet thick, with a band of Gryphea as in No. 7, but without the Scaphite nodules.
9. *Ferruginous Sands.*—Sands highly ferruginous, with layers of dark-blue clay, and bands of ironstone nodules full of casts of shells (Pl. IV. fig. 7, Pl. V. fig. 1), of the genera Venus, Thetis, Trigonia, &c. Seams of lignite are disseminated through the lower beds in undulated laminæ; and thin layers of ironstone grit without fossils occur in the upper part of the series. The beds in contact with the galt are generally of this character.

In the upper 250 feet of the greensand but few organic remains are met with, and the strata are more or less highly charged with peroxide of iron. "Everything," says Professor E. Forbes, "in this stage appears to indicate a shallow and barren sea, probably from an elevation of the sea-bottom, previous to a new state of things, when a fresh series of clays, forming the galt, being deposited, the majority of the animal forms which characterise the clays of the greensand disappear, and are replaced by distinct species, representative in time."*

NEOCOMIAN OR ATHERFIELD STRATA.—The inferior portion of greensand at Atherfield, from the lowest bed to the Crackers inclusive, abounds in fossils which are either very rare or altogether absent in the upper part of the series. A group of subcretaceous deposits near Neufchatel, in Switzerland, having lately been found to contain many species of shells not previously known in other parts of the cretaceous system, has, in consequence, been described by some eminent French geologists as a distinct formation, belonging to a period antecedent to the deposition of the greensand, and synchronic with the Wealden; and they have designated the group *Terrain Neocomien.* But Dr. Fitton has shown, by a careful comparison of a large number of the French fossils with those from Atherfield, that so close an agreement exists in the organic remains as to leave no reasonable doubt that the so-called Neocomian strata are but the equivalents of the lower series of the English greensand system.†

In a Report read before the British Association of Science, at Southampton,‡ Dr. Fitton gave a table of 150 species of shells, the stratigraphical position of which has been accurately determined. From this it appears that 130 species occur in the lowermost 150 feet of strata; and that in the upper beds, comprising a thickness of nearly 700 feet, but twenty additional species are met with; the absolute number of fossils also rapidly diminishes, but few, if any, organic remains appearing in the uppermost layers. But throughout this period of consecutive deposition, one series of fossils only is indicated, bounded by the Wealden below and the galt above. It is the lowermost part of the Atherfield section which is regarded as the equivalent of the remarkable fossiliferous group of Neufchatel. The principal difference between the continental and English greensand fauna, is stated by Professor E. Forbes to consist in the abundance of gasteropoda and cephalopoda in the former, and of acephalous bivalves in the latter.

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* "Geol. Journal," 1845.

† The name *Neocomian* is introduced in the section, lign. 17, p. 157, to elucidate these remarks.

‡ In September, 1846.

GREENSAND FOSSILS.*—The organic remains of the greensand to be met with along this coast are almost exclusively shells; but few traces of the higher orders of animals, or of plants, have hitherto been observed. It should, however, be borne in mind, that remains of land reptiles, and trees, and plants, have been found in strata of this formation in Kent; similar relics may therefore occur in the same deposits in the Isle of Wight.†

Of the vegetable kingdom but few vestiges have been discovered. The laminæ of lignite in the upper ferruginous beds, and obscure traces of fuci in some of the lower sandstones, are the only indications of the flora of this geological epoch that have come under my notice. But remains of the foliage of a fern that abounds in the

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* The finest collection of the organic remains of the greensand of the Isle of Wight is, I believe, that made by Captain Ibbetson, and now exhibited in the Polytechnic Institution of London. The Geological Society has the most complete series of the shells, principally contributed by Dr. Fitton, and named by Professor Forbes. Figures of most of the species will be found in "Mineral Conchology," Dr. Fitton's "Memoir," and in the "Geological Journal," vol. i.

† See "Wonders of Geology," vol. i. p. 394.

Wealden (*Lonchopteris Mantelli*, lign. 21) were discovered by Mr. Morris in many of the strata at Atherfield; and the Messrs. Gladstone have since found several leaflets of the same species associated with trigoniæ, &c., in ironstone nodules at the foot of Shanklin Cliff. This interesting fact we shall have occasion to notice in a subsequent chapter. Of the poriferæ and corals but few species occur. Traces of bulbiform *siphonia* (apparently *S. pyriformis*, Dr. Fitton's "Memoir," Pl. XV.) are sometimes displayed on the waterworn surface of fallen blocks of sandstone. A small elegant coral, a species of *astrea*, is not uncommon in the Cracker's Rock at Atherfield.

The lowermost beds at Atherfield Point being very fossiliferous, the collector will have but little trouble in obtaining good specimens of the shells distributed in those strata: the *perna mulleti* (Pl. IV. fig. 6) may generally be extracted tolerably perfect.* From the nodular masses of the Crackers, with which the shore at low water is often thickly strewn, an abundance and variety of shells may be procured; and that part of the cliff where the two parallel layers of these concretionary masses are within reach (almost half a mile to the east of Atherfield Point), will afford specimens at all times. The large *gryphea sinuata* (Pl. V. fig. 3) may be found everywhere along the shore; the shell being sufficiently strong to resist for a time the action of the waves, clean and perfect examples often occur imbedded in the sand. Beneath Walpen High-cliff, and at Whale's Chine, the gryphea bed may be examined *in situ;* the *terebratula sella* (Pl. V. fig. 5) may be obtained from the loose green sand (No. 6, p. 165) in great perfection and variety.

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* It is necessary that the geologist should so arrange the time of his visit to this coast as to arrive at Atherfield at the beginning of the ebb of the tide, that he may be able to examine the cliffs and collect specimens at leisure.

The magnificent cephalopodous shell, the *Scaphites grandis*[*] (*S. gigas* of our Pl. V. fig. 11), is most likely to be met with near the base of the same part of the cliffs. Some fine specimens have been found along the shore near Ladder Chine; and very large ammonites and nautili occur in the same locality. On the shore, not far from the base of Blackgang Chine, nodules with scaphites may be observed above a bed of sand full of terebratulæ.

The fossil lobsters, the most beautiful of the Atherfield fossils, may generally be met with after recent slips of the cliff involving masses of the strata (Nos. 3 and 5, p. 164, 165), in which they occur. The vignette of this volume (engraved by Mr. Lee from a drawing by Mr. J. Dinkel) represents an exquisite specimen from a fallen block lying near the pathway at the foot of Atherfield Cliff.

Minute bones of fishes in the lowermost clay, and a few teeth of the *shark* family, are the only remains of vertebrate animals I have observed; but Captain Ibbetson has obtained from these cliffs a specimen of extraordinary interest. It is a considerable portion of the skull, with the bones of the face and the jaws and teeth attached, of a species of *hybodus;* a genus of fishes of the shark tribe, having teeth of a transversely elongated form, with a series of compressed conical cusps, of which the middle one is the longest.[†]

In this remarkable fossil the mouth is open, and forms a semilunar aperture six inches wide. The upper jaw has twenty-four teeth, and the lower nineteen, in their natural position; two rows of successional teeth are traceable behind the anterior series. These teeth, as shown in lign. 19, have a central cusp rather hooked, and two lesser points on each side.

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[*] The shell has been described under different names, as Crioceras Bowerbanksii, Scaphites gigas, &c.; the latter name is given in the description of Pl. V., but Professor E. Forbes has adopted that originally affixed to this gigantic cephalopod by Mr. Sowerby. *Scaphites* are distinguished from *ammonites* by the disunion of the whorls, and from *hamites*, by the spiral arrangement of the posterior volutions. A very small species of scaphite (not exceeding an inch in length) is frequent in the chalk marl. See "Medals of Creation," vol. ii., for an account of fossil *Cephalopoda.*

[†] "Medals of Creation," vol. ii. p. 622.

LIGN. 19—FIVE TEETH ATTACHED TO A PORTION OF THE JAW OF A FISH OF THE SHARK FAMILY; FROM ATHERFIELD.

(*Hybodus bassanus, of Sir P. Egerton.* "Geol. Journal," vol. i. pl. iv.)

The *hybodonts*, like other fishes of this family, were armed with strong dorsal spines, which are often found in the lias, oolite, and Wealden strata; and, rarely, in the chalk.*

THE CLIFFS AT BLACKGANG CHINE.—Proceeding from Atherfield Cliffs eastward, the first interesting point is Blackgang Chine; a spot well known to every tourist who visits the Undercliff. Viewed from the sea-shore at low water, especially when the springs which feed the waterfall have been swollen by heavy rains, the effect is highly picturesque. The cascade falls in a perpendicular column from a ledge 70 feet high, down the midst of a deep chasm formed in dark ferruginous clays and sands, and surmounted by broken cliffs 400 feet high; and towering above all is the majestic escarpment of Saint Cathe-

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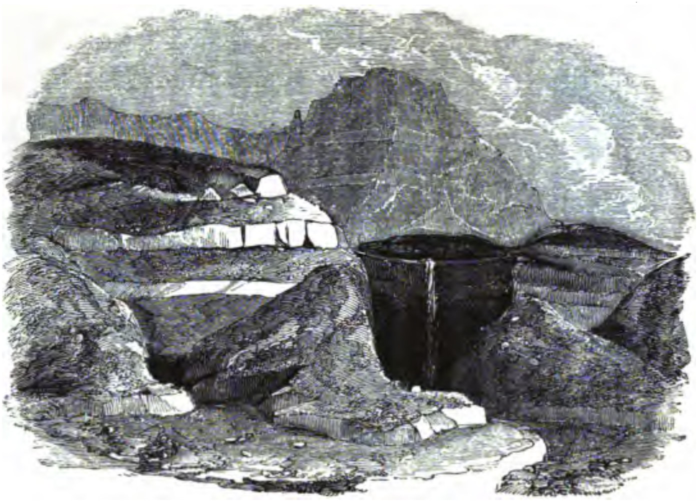
* Capt. Ibbetson's specimen is in the Polytechnic Institution on a pedestal at the entrance of the Isle of Wight model-room. It is figured and described by Sir Philip Egerton in "Geol. Journal," vol. i. p. 197. Unfortunately, the drawing was made before the bones of the face and jaws were cleared of the adherent stone, and it therefore represents only the margin of the jaws with the teeth, surrounded by a shapeless mass.

Pl. XII.



BLACKGANG CHINE; FROM THE SEA-SHORE.

rine's Hill, rising to an altitude of between eight and nine hundred feet. The sketch in Pl. XII. shows the section exhibited in the face of the cliffs. The bands of greenish-grey sand and sandstone which alternate with ferruginous clays in this division of the greensand system, appear very prominent, owing to the wearing away of the soft and friable intermediate beds.

As the face of the sandstone, after long exposure to the atmosphere, separates into square blocks, the appearance of the projecting bands of stone, which are from ten to fifteen feet thick, is very singular, and is not unaptly compared by Sir H. Englefield to courses of masonry built up at different heights to sustain the mouldering cliffs. The thin layer of ironstone grit which, as we have previously remarked, is very constantly found in this division of the greensand, constituting as it were a line of demarcation between the upper arenaceous deposits and the lower more argillaceous group, intercepts the water that percolates through the upper porous strata, and projecting in a ledge forms the bed of the stream that falls in a cascade over the face of the cliff.

In reference to the springs along this coast it may here be remarked, that no less than ten copious streams issue from the strata on the south side of the range of hills facing the Undercliff, and run directly into the sea; most of those which flow from the greensand are chalybeate.* At Sandrock, near Blackgang, is a celebrated aluminous chalybeate spring, of which an analysis was published by Dr. Marcet in "Geol. Trans." vol. i. This water is highly charged with sulphate of iron and alumina. It rises from a bed of sand within fifty feet of the galt.

THE UNDERCLIFF.—We have now arrived at the western extremity of that interesting and picturesque region known as the Undercliff of the Isle of Wight; and which may be described geologically as a miscellaneous accumulation of debris, principally composed of fallen masses of the upper cretaceous strata, occasioned by the encroachments of the sea on the lower argillaceous and sandy deposits that form the base of this line of coast. The Undercliff consists of an irregular terrace, sloping towards the south, from a quarter to half a mile in breadth, and six miles in length; its elevation above the sea is from 100 to 400 feet. It is protected on the north by the escarpment of the southern chain of hills, which forms a line of vertical cliffs, from 200 to 400 feet high, and extends from St. Catherine's to Shanklin Down.

There is perhaps no tract of such limited extent that affords so remarkable an instance of the modification of climate induced by geological structure and physical configuration as the Undercliff. Completely sheltered on the north by the range of chalk cliffs—elevated above the influence of the mists and fogs of the sea-shore—possessing a soil composed of the detritus of chalk and sandstone, which rapidly absorbs and carries off superfluous moisture, yet supports a luxuriant vegetation—with an undulated and varied surface enjoying throughout its whole extent a southern aspect—and fanned only by breezes which invigorate but do not chill—this fairy region well merits the high encomium of the medical philosopher. It is, indeed, what Sir James Clark, in his invaluable work on Climate, has described it to be—"a lofty natural terrace backed by a mountainous wall on the north, and open on the south to the full influence of the sun from his rising to his going down, during that season when his influence is most wanted in a northern country. The climate is remarkably equable as well as mild and dry, and there are not many days during the winter on which the invalid cannot take some exercise in the open air. The mildness and dryness of the climate during the winter months may be in some degree estimated by the circumstance of myrtles, geraniums, and various tender greenhouse plants usually withstanding the winter in the open flower-borders. The absorption of heat by the almost perpendicular cliffs of the Undercliff, exposed as they are to the rays of the sun during the whole day, must be considerable, even in winter: and the radiation of this heat during the night no doubt tends to equalize the temperature. To the invalid who has a taste for natural history, this sheltered district and neighbourhood possesses an additional advantage. It is rich in varied and interesting plants: indeed, the specimens of natural history with which it abounds offer abundant inducements to exercise, and healthful mental occupation, to the cultivators of this delightful science."* How great will be my reward, should these humble pages open a new source of intellectual enjoyment to any of those who may repair to this favoured spot, for the restoration of health, or the alleviation of mental affliction.

GEOLOGICAL STRUCTURE OF THE UNDERCLIFF.—The structure of this district will be readily understood by an examination of the western extremity of the Undercliff. The diagram, lign. 17 (p. 157), illustrates the position of the several groups of the cretaceous beds at St. Catherine's Down, which is 830 feet in height; the strata are nearly horizontal. The greensand series reaches to the top of the cliff at Blackgang, upwards of 400 feet high; the galt lies above it, and forms a bed more than 100 feet thick. The marls, sands, and calcareous sandstones, comprised under the name of firestone, in thickness about 100 feet, next appear, and rise into a vertical inland cliff, half a mile from the shore. Strata of white chalk form the summit of St. Catherine's Down, the total thickness amounting, in some places, to 250 feet; but on the south-western brow of the hill these beds thin out, and form a mere capping over the firestone.*

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* "The Sanative Influence of Climate," by Sir James Clark, Bart., M.D., &c. Fourth edition. London, 1846.

The galt is seen at the top of the ravine west of Blackgang Hotel, resting upon the greensand which extends in a terrace beyond it. Some of the fossils peculiar to this deposit (*Inoceramus sulcatus*, and *I. concentricus*) have been obtained from this place. This bed also appears beneath the firestone on the face of the cliff east of the Sandrock spring, above the road leading to Ventnor.

The firestone in the southern face of St. Catherine's hill, above the road from Niton, presents the usual characters of this group as they appear in a succession of terraces along the Undercliff.† The chalk-marl forms the upper part of the series, and passes downwards into greenish grey sands and calcareous strata, in which are layers of bluish marl rock. Strata of cherty sandstone, alternating with layers of sandy marl, occur in the lower part: and from the disintegration and removal of the intermediate earthy beds, the chert appears in projecting ledges along the face of the southern escarpment of the downs, through a considerable extent of the Undercliff. This circumstance imparts a peculiar feature to the landscape, and, under certain combinations of rock and vegetation, contributes greatly to the picturesque character of the local scenery:‡

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* Mr. Lowry, the eminent engraver, informs me that the firestone reaches to within 133 feet of the beacon on St. Catherine's Down, as he ascertained by barometrical observation in 1837.

† The firestone strata in the Isle of Wight are more numerous and diversified than in Kent and the south-east of Sussex, and resemble the equivalent deposits in the western district of Sussex and Hampshire, so ably elucidated by Sir Roderick Murchison, in his first contribution to that department of natural philosophy, the boundaries of which his genius and important researches have since so largely contributed to extend.—See "Geol. Trans." vol. ii. Second series, 1826.

‡ Captain Ibbetson, whose beautiful and accurate models of the Undercliff are exhibited in the Polytechnic Institution, sub-

The layers and concretionary masses of chert are principally distributed in the upper part of the series; and beneath them are sands, and a bed of sandstone from two to four feet thick, which, though soft when first extracted, hardens by exposure to the air, and becomes an excellent building material. The ancient churches on the south side of the Island have been constructed of this stone, and it is being largely quarried for the edifices now in progress of erection.

FOSSILS OF THE FIRESTONE STRATA.—The fossils of the arenaceous and cherty strata of the firestone group comprise many species which also occur in the uppermost deposit, the chalk marl; and likewise several that have either not been observed, or are very rare in the other strata. They consist of several kinds of ammonites, nautili, hamites, scaphites, and other cephalopoda; numerous bivalves, especially pectens, terebratulæ, trigoniæ, &c., and of a few genera of simple univalves, as *cirrus*, *trochus*, *avellana*, &c. The bare enumeration of the species would occupy a considerable space, and be unintelligible, except to the scientific reader, without the aid of figures.

There is, however, one fossil which it is necessary to describe, from the abundance of its remains which meet the eye in almost every block of firestone. It is a species of *siphonia* (*S. Websteri*), a zoophyte resembling the sponge in its porous structure, but possessing numerous tubular channels that permeate the general mass, and communicate

divides the firestone group into the following:—1, Upper greensand; 2, Chloritic marl; 3, Second bed of greensand; 4, Fossiliferous marl, in which large scaphites occur; 5, Two alternations of malm and rag: the term *malm* is applied to a firm argillaceous rock, and *rag* to the cherty sandstone that alternates with the former. A very large collection, comprising numerous species of shells, zoophytes, &c., has been obtained from these strata, and especially from the fossiliferous marl.

by openings into a central cavity.* This species is in the form of an oblong bulb with a shallow opening, supported upon a long slender stem, having a root-like base by which the original was attached to the rock. This fossil was first figured and described by Mr. Webster, under the name of *tulip alcyonium*. The bulbs and stems are often disposed in relief on blocks that have been weathered, or washed by the sea; for the fossils, being harder than the surrounding stone, more effectually resist abrasion, and large surfaces of firestone are therefore covered with their remains, which, being whiter than the rock, are very conspicuous.

Fossil Cycadeous Plant.—But the fossiliferous marl (as Captain Ibbetson designates the bed most prolific in organic remains) has lately been found to contain relics of a higher order than any previously known to occur in the cretaceous strata of the Isle of Wight. In the collection deposited in the Polytechnic Institution, there is a specimen from the marl near Ventnor, that several years ago attracted my attention, but which I was unable to obtain an opportunity of examining till a few weeks since, when Captain Ibbetson, with great liberality, permitted me to inspect and figure it for this work. It proved to be, as I had conjectured, the summit of a stem, surrounded by the petioles, or leaf stalks, the leaves themselves having either been shed or decayed, of the *Clathraria Lyellii*, a cycadeous plant, hitherto only known in the Wealden formation. A figure (lign. 23) and description of this most interesting relic, will be given in the account of the organic remains of the Wealden in Chap. X.

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* "Mr. Webster on some new varieties of Fossil Alcyonia."—"Geol. Trans." vol. ii. First series, p. 376. Mr. Webster mentions that the first specimens, showing the connection of the stems and bulbous part, were observed on some "stupendous and difficultly-accessible masses of rock lying under the romantic cliffs of Western-lines." The branches vary in size from half an inch to three inches in diameter, and from six to eighteen inches in length; they terminate above in a bulb or head, somewhat resembling in form a closed tulip, and from one to six inches long; the other extremity branches into root-like fibres, by which these bodies, when living, were attached to rocks or stones. If the stems and bulbs are broken transversely, they are found to consist of bundles of longitudinal tubes; and this internal structure is generally silicified, so that polished sections are very interesting. I need scarcely remind the reader that these bodies have no relation to the alcyonia, which are polypiferous zoophytes; whereas these fossils are simply a congeries of tubes and pores, like certain sponges. The fossil that is figured in my "Medals of Creation" (vol. i. p. 259) as *Siphonia Websteri*, is not that species, but *S. pyriformis* of Goldfuss, which generally occurs in the greensand, but is occasionally met with in the firestone, and in the grey chalk, associated with another common fossil sponge, the *Scyphia meandrina*.

Fossil Femur of a Reptile. (?)—Another discovery, not less important, has recently been made in the easternmost quarry, above Bonchurch, and was communicated to me by S. M. Saxby, Esq., of Bellevue House, Ventnor; a gentleman to whom I am indebted for many interesting local details relating to the strata and fossils of the Undercliff. The specimen referred to is either the *humerus* (arm-bone) or *femur* (thigh-bone) of a terrestrial animal, probably of a gigantic lizard. It is broken transversely, and some two or three inches of the middle portion of the shaft are missing, but the articulating extremities are in excellent preservation. So far as a hasty inspection would enable me to form a conjecture of the affinity of this bone to recent types, it appears to approach nearest to the femur of the Monitor or Iguana; most certainly it bears no resemblance to the corresponding bone of any of the Wealden reptiles that have come under my notice. The lower portion is 9 inches in length, and terminates at its distal extremity in two large laterally compressed condyles, having a very wide *popliteal* space between them; the anterior or *patellar* aspect is smooth, and but little depressed. The transverse diameter of the bone at the condyles is 6½ inches; the upper and fractured end of the shaft is 3¼ inches in diameter in the same direction. The proximal extremity, or head of the bone, is somewhat compressed, and its characters are concealed by adherent firestone; it is 7 inches wide in the transverse and longest diameter. This portion of the bone is one foot in length; the transverse diameter of the inferior and fractured end is 4 inches; and as the corresponding part of the shaft of the distal portion is 3¼ inches, it is obvious that the lost intervening piece of bone must have gradually diminished in circumference 2¼ inches, from above downwards. The shaft in the transverse diameter measures 4 inches; in the antero-posterior, only 3 inches. But the most remarkable character of this bone is the relatively enormous size of the medullary cavity, which is 3 inches by 2; the walls of the bony cylinder at the fractured part being only half an inch thick. I have not been able to procure a fragment for microscopical examination, by which its reptilian or mammalian affinity might be determined: but for the courtesy of Mr. Saxby, even these brief details could not have been obtained.*

FOSSIL FUCI.—White ramose and meandering lines are not uncommon on the surface of the sandstone: these are probably vestiges of fuci or other marine plants. A well-known delicate species, the *Fucoides Targionii*,† that abounds in the malm-rock of Bignor in Sussex, occurs sparingly at Ventnor. Some very curious trifid impressions are sometimes observable on the surface of waterworn blocks of sand-rock, and are possibly referable either to this tribe of plants, or to some kind of siphonia. Some of these imprints so closely resemble, both in form and in their arrangement on the surface of the slabs, the supposed *Ornithicnites*, or footsteps of birds, that occur in such perplexing abundance and variety in certain ancient secondary rocks of the United States,* that Mr. Saxby, who first observed these fossils, was at infinite pains to ascertain their nature. The examples hitherto obtained, though very specious in appearance, cannot, I conceive, be regarded as the imprints of the feet of any animal: unequivocal evidence as to the origin of these problematical objects is still desirable.

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* Mr. Saxby has kindly informed me that the quarry at Bonchurch is precisely at the commencement of the land-slip by the turnpike road, and the layer in which the bone was found is three or four feet above the firestone.

† "Medals of Creation," vol. i. p. 105.

MOLLUSKITE.—The soft bodies of the testaceous mollusca often occur in a fossil state, changed into a brown carbonaceous substance, which I have proposed to distinguish by the term *molluskite*.† When empty shells are found enclosed in rocks, the mineral matter generally fills up the cavity and forms a cast of the interior: but if the animal occupied the shell at the time it was imbedded, the soft parts appear to have become changed into a brown or black substance, which in some instances retains the form of the original, but in general occurs as an amorphous mass, containing a large proportion of animal carbon. In the greyish green sands of the firestone of Kent and Sussex this substance often occurs, and it is equally abundant in some of the sandstones of the Undercliff. The brown spots dispersed through the stone forming the mouldings and mullions of the new church at Ventnor are composed of molluskite. In recently extracted stone at Ventnor, I have observed shells of trigoniæ, rostellariæ, and cucullea filled with this carbonaceous matter. The shelly limestones of the Wealden called Sussex and Purbeck marbles, are mottled with black molluskite, consisting of the carbonised remains of the river snails of which the limestones are composed.

SOUTHERN RANGE OF CHALK DOWNS.—From this digression on the zoological characters of the middle system of the chalk formation, we resume our geological survey of the southern coast. Before we climb St. Catherine's Hill, let the observer for a moment take another glance at the view commanded by the terrace in front of the Blackgang hotel, which affords a *coup d'œil* of the south-western shores. Looking down the ravine immediately at our feet, the aspect of the scene is singularly wild and dreary, from the sombre colours and fantastic masses of the broken walls of the chine, and the gloomy shade thrown athwart the chasm by the projecting cliffs. On the coast, the greensand strata are seen stretching on to Atherfield Point; and beyond may be distinguished Brook Point, which from this elevated spot appears as a low promontory; and farther west are the chalk cliffs, gradually vanishing away towards the Needles.

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* Ibid, vol. ii. p. 810.

† "Medals of Creation," vol. i. p. 431.

Ascending St. Catherine's Hill, a magnificent panoramic view bursts upon the sight. From the summit, a height of between eight and nine hundred feet, when the atmosphere is clear, the eye commands at one glance the grand features of the physical geography of the Island, and the range and extent of the principal groups of strata. We are now on the western extremity of the southern range of chalk downs, which, as previously explained (*ante*, p. 129), is separated by a considerable district of greensand from the central chain of hills.* This system of chalk downs varies in breadth from half a mile to three miles, and extends six miles in a direction E.N.E. and W.S.W. from St. Catherine's Hill to Dunnose, its eastern termination, which is nearly 800 feet high. The intermediate parts of the range maintain an elevation of from 650 to 800 feet, with the exception of a deep valley on the east of St. Catherine's, through which the road to Niton passes; and another at Steephill, called the Shute or Shoot, above

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* Refer to the diagram, Pl. VII., and the map, Pl. XX.

Ventnor, traversed by the road to Appuldurcombe and Newport. A marl bank on the side of the Shute abounds in fossils.*

The strata of these hills are nearly horizontal, having only a slight inclination to the south-east. From Ventnor to St. Boniface Down, above Bonchurch,† a distance of three-quarters of a mile, the usual smooth verdant character of the chalk is resumed, and the hills rise to the height of 800 feet, sending off to the northward the lofty range of Shanklin Down, and terminating in Dunnose Point.‡ The

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* Mr. Saxby informs me that he has obtained from this locality turrilites, ammonites, nautili, belemnites, and many other marl fossils.

† High up on the slope of the hill bursts forth a spring called St. Boniface's Well, to which local legends have attached much veneration.

‡ DEVIATION OF THE PLUMB-LINE AT SHANKLIN DOWN.—During the progress of the Ordnance survey, a deviation of the plumb-line from its mean direction was observed in the neighbourhood of Shanklin Down, by Col. Colby, the Director of the Trigonometrical Survey; a considerable attraction of the plumb-line to the south of the Dunnose station having been unequivocally determined, and which is supposed to depend on the intensity of the attraction of the hill. In alluding to this remarkable phenomenon, Sir Roderick Murchison (in his address at the meeting of the British Association of Science at Southampton, September, 1846) observed, "that it is a matter of surprise that this comparatively low chalk range in the Isle of Wight should attract, in one parallel at least, with more than half the intensity of the high and crystalline mountain of Schehallien in the Highlands of Scotland.[a] Can this be explained by the peculiar structure and distribution of the ridge of upheaved strata which runs as a back-bone from east to west through the

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[a] In the year 1774, from astronomical observations made on the mountain of Schehallien by Dr. Maskelyne, it was proved that a sensible disturbance was produced in the direction of the plumb-line by the attraction of the dense masses of granular quartz and limestone, and mica and hornblend slate, of which that mountain is composed.

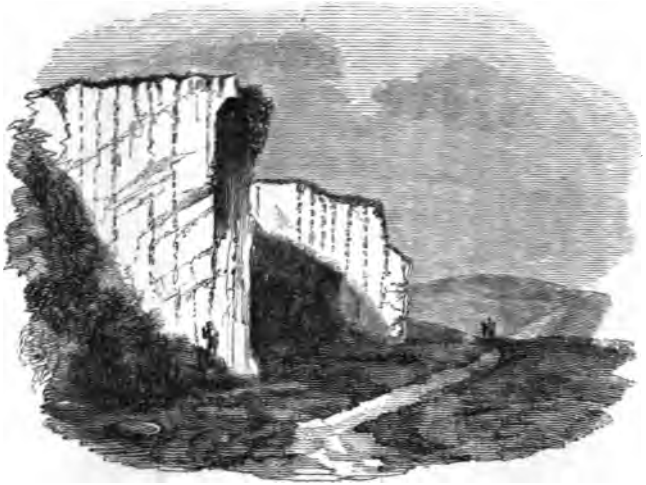
siliceous nodules in these strata are always found entire; presenting in this respect a striking contrast to the shattered flints in the vertical strata that form the opposite range at Brading Down. (See Pl. XIII.)

COAST OF THE UNDERCLIFF.—The district of the Undercliff, from the western extremity of St. Catherine's Hill to Bonchurch, is about six miles; and the road from the west passes along an irregular terrace composed of fallen masses of chalk, marl, and firestone, which in the lapse of centuries have accumulated in a talus on the southern escarpment of the Downs. Although subsidences are occasionally taking place, and within the last hundred years from eighty to ninety acres of the upper cliff sank down at one time, the greater part of this singularly picturesque and lovely region has undergone no material change since the Conquest. This is evident from the ancient churches of St. Lawrence and St. Boniface, which are referred by antiquaries to the eleventh or twelfth century.* In travelling from Blackgang to Ventnor, the firestone cliffs are the most important geological feature. Here and there on the road-side are seen accumulations of debris, and projecting crags of chert and sandstone, which from their superior hardness have for years resisted the disintegrating effect of the elements. From the intermixture of calcareous and argillaceous earth resulting from the decomposition of the strata, a soil has been produced which supports a luxuriant vegetation. Even the refractory siliceous rocks are more or less clothed with foliage, for the ivy has insinuated itself into every cranny, and hangs in festoons of verdant tapestry over the cherty peaks.

Island? or is it to be referred to the effect of dense masses of plutonic rock ranging beneath the surface along the line of displacement of the deposits?"

* Sir Henry Englefield; "Isle of Wight."

Pl. XIII.



VERTICAL CHALK STRATA, WITH LAYERS OF SHATTERED FLINTS; IN A QUARRY ON BRADING DOWN.

In many places the fallen blocks of sandstone are covered in relief with stems and bulbs of the *Siphonia Websteri* (*ante*, p. 177), and contain numerous shells. At Ventnor there are (or were) some bold vertical sections of the firestone; and an enormous mass of rock overhangs the road east of the Marine hotel. The calcareous sandstone here abounds in shells and molluskite. The terrace and sea-cliffs that form the southern boundary of this rapidly-increasing town are entirely composed of fallen masses of the upper groups of the cretaceous strata. In many instances huge fragments of white chalk appear imbedded in the greensand of the firestone; and I observed (in 1844) a series of chalk strata forty feet in thickness, surmounted by many feet of marl and firestone, forming a low headland on the sea-shore, the entire mass having been retroverted in its fall from the heights above. The diagram in lign. 20, p. 188, will serve to elucidate the above remarks.

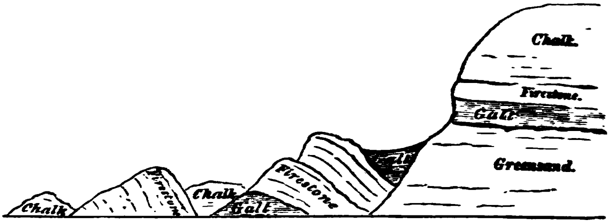
The vicinity of Ventor is rich in the shells and zoophytes of the cretaceous system. The following localities have been pointed out to me by Mr. Saxby:—

The bank on the roadside at the Shute, above Ventnor, abounds in chalk-marl fossils.

Horse-shoe Bay, in black malm rock; many shells. Under the cliff to the east, called High-port, at low water, nodules of pyrites, generally having a terebratula or other shell as the nucleus.

East of Colin's Point and Mill Bay, the galt is visible and contains shells. In a highly-inclined fallen mass of sandstone, sharks' teeth, coprolites, molluskite, and many shells. Firestone with fossils occurs on the shore, eastward of the Parsonage.

In the gravel-pits on "Little-town Down," above Ventnor, the flints abound in sponges. They sometimes contain a sharp conical body fixed by its base, and projecting into an elongated fusiform cavity. This appearance has been produced by a *belemnite*, of which the large cavity is the impression, and the conical body the cast of the *phragmocone*, or chambered shell of this curious cephalopod.*



LIGN. 20.—SECTION OF THE UNDERCLIFF, NEAR VENTNOR.

In the chalk marl above Bonchurch numerous fossils, comprising turrilites, scaphites, ammonites, incocerami, &c., have been found. The bone of a reptile and the stem of clathraria, previously described (*ante*, p. 179,) were obtained from this locality.

THE COAST FROM VENTNOR TO SANDOWN BAY.—From Rocken-end, east of Blackgang Chine, to Bonchurch, the sea-cliffs, in consequence of the displacements which have produced the Undercliff, present no continuous sections of the strata of sufficient importance to require especial notice. It may be briefly stated, that after passing along that ruinous district, and arriving at the eastern termination of the promontory formed by the southern chalk downs, a repetition of the section observable at St. Catherine's Hill on the western extremity, is presented to view on the east of Bonchurch Cove, at Dunnose Point and Shanklin Down. This section of the nearly horizontal strata of chalk, firestone, galt, and greensand, is shown in the diagram, lign. 9, p. 96. The *white chalk* forms the upper series of deposits; of the firestone, which varies in total thickness from 70 to 100 feet, a good section is seen above the ravine at Luccomb, between Bonchurch and Shanklin. The galt underlies the firestone as at Sandrock, near Blackgang; and beneath are the ferruginous sands and dark clays of the greensand. The layer of ironstone nodules full of casts of shells (see *ante*, p. 165) extends through the upper part of the cliff at Dunnose; but the *perna mulleti* bed has not been observed along this part of the coast.

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* See "Medals of Creation," vol. ii. p. 459.

Luccomb Chine, which lies between Chine Head and Dunnose Point, is an extensive gully like that of Blackgang, formed by springs derived from the high land on the north-west, and which, falling over a perpendicular cliff of sand and clay, have worn a deep ravine that is slowly receding from the shore. The celebrated chine of Shanklin is of the same character: the cliff here is 230 feet high, and the chasm extends 150 yards from the shore, being 300 feet wide at the top, and narrowing down to the bed of the torrent. The steep sides of the ravine are clothed with verdure and overshadowed by underwood, except where bare masses of rock protrude, and contribute to the picturesque effect of this romantic glen.

The character of the scenery around Shanklin so entirely depends on the geological structure of the country, that I am led to transcribe the following vivid description of this part of the Island by Sir H. Englefield:—"As we approach the village of Shanklin, its appearance is equally singular and interesting. It is seated in a small vale hanging towards the sea, at a great height above that level; the houses are detached from each other, and almost buried in groves of elms; and every cottager, however humble, being in the habit of letting lodgings in the summer season, surrounds his dwelling with a garden full of flowering shrubs. The whole spot has a most cheerful and uncommon character. The little church, which is of a pretty form, stands on a broken knoll open to a beautiful pasture, with groups of elms carelessly disposed about it; and it is backed by the high hill of Dunnose, whose lower part is covered with thickets and groves hanging down its steep sides.

From among these in one part a range of rocks starts out; the northern face of the same great stratum to which the Undercliff owes its existence and its beauty. The route from Shanklin church, by the road which winds through the open groves up the flank of Dunnose, is eminently beautiful, affording, as we ascend, the most lovely views. The village, with its groves, forms a charming first distance —the bay of Sandown with the Culver Cliffs present a noble winding shore; and beyond the low land of Sandown, in the direction of Brading Haven, a part of the anchorage of Portsmouth with its shipping is visible. From the top of the ascent the elevation of the ground is so much greater than the chalk hills of Yaverland, that the sea is visible over them; and the distant blue heights of Hampshire and Sussex form an uninterrupted line, till to the eastward they are blended with the horizon of the sea; emerging out of whose waters the white cliffs from Brighthelmston quite to Beachy Head are distinctly visible, though from forty to sixty miles distant."*

The western cliff of Shanklin Chine consists of an alternating series of clays and sands. The upper part is greenish-white sand, resting on a bed of dark-blue clay; beneath this is another stratum of sand, and a second bed of clay lying on a deposit of greenish-grey sand, with bands of sandstone. The lower part consists of ferruginous sands, with concretionary layers of greensand full of terebratulæ. The argillaceous partings have given rise to narrow ledges, which are verdant from a covering of rank grass; but slips are continually taking place from the wasting away of the sand, by the oozing of the water arrested in its descent from the porous strata above, by these beds of clay.

Along this shore numerous specimens of the gryphea sinuata are generally to be met with loose in the sea-sand, as at Atherfield; and ironstone concretions, full of shells that have fallen from the cliffs. In these nodules, leaflets of the Wealden fern (lign. 21) are sometimes found associated with trigoniæ, terebratulæ, &c.

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* Sir H. Englefield's "Isle of Wight," p. 70.

At the foot of the cliff near Shanklin Chine, the lower series of greensand strata emerge, and gradually rising to the surface, form the western coast of Sandown Bay. The view of the bay from Shanklin is extremely interesting, for the white chalk strata of Culver form the eastern promontory, and the galt, firestone, and greensands of Redcliff, succeeded by the low Wealden cliffs, may be distinctly traced.

Beyond the cliffs at Sandown is the vale of Newchurch, a low alluvial plain, protected from the inroads of the sea only by a thick bed of shingle; beneath which, at low water, the Wealden clay may be seen extending under the greensand strata on the east and west. The little inn on the shore and the fort now appear, and we reach the spot where our examination of the eastern side of Sandown Bay terminated.

Our excursions have now extended round the Island, and embraced the whole series of coast sections, with the exception of the Wealden cliffs that intervene between Compton Bay and Atherfield Point. A visit to Brook Bay will enable us to complete our survey, by an investigation of those highly interesting natural records of one of the most remarkable epochs in the physical history of our globe.

CHAPTER IX.

THE WEALDEN FORMATION—NATURE OF RIVER DEPOSITS—WEALDEN STRATA OF THE ISLE OF WIGHT—EXCURSION TO BROOK BAY—CLIFFS FROM COMPTON CHINE TO BROOK POINT—BROOK POINT—PETRIFIED TREES—STRUCTURE OF THE FOSSIL WOOD.

THE WEALDEN FORMATION.—The lacustrine and fluviatile origin of the strata spread over the northern part of the Island was clearly denoted by the prevalence of land and freshwater shells, and the remains of aquatic and terrestrial plants; and by the presence of bones of mammalia related to the tapir, peccari, &c., but referable to extinct species and genera; while the marine and estuary shells, and other exuviæ, in the deposits on which the freshwater beds were super-imposed, afforded conclusive evidence that these strata were formed in the basin of a comparatively shallow sea.

The cretaceous system, which so long engaged our attention, displayed, on the contrary, an assemblage of sedimentary deposits that had been accumulated in the profound depths of the ocean, in a period of unfathomable antiquity and of long duration. The innumerable relics of marine organisms showed that then, as now, the sea was teeming with life; while a few vestiges of terrestrial plants and animals attested the existence of dry land, inhabited by oviparous quadrupeds and clothed with vegetation, during the formation of this series of oceanic deposits.

The natural records of an antecedent epoch are now before us, and we proceed to examine an assemblage of strata, not of marine, but of freshwater origin, that was deposited ere the formation of the cretaceous rocks commenced; for these fluviatile sediments constituted the sea-bottom, over which was spread the first layer of the greensand (see p. 162). From the extension of these deposits over the Wealds of the south-east of England, and from their fluviatile characters having in the first instance been determined by observations on the strata and organic remains discovered in those districts, the formation has received the name of The Wealden.

Before entering upon the examination of the cliffs in Brook Bay, which will form the principal object of the present excursion, a few general observations on river deposits, and on the information to be derived from their investigation, as to the nature of the land, and its fauna and flora, may be necessary to enable the unscientific reader justly to appreciate the geological interest of the phenomena that will demand his notice—phenomena which, if rightly interpreted, will reveal a former condition of the earth's surface, more marvellous than any which even the wildest imagination has ventured to portray.

NATURE OF RIVER DEPOSITS.—The torrents that rush down the mountains' sides, and the streams and rivulets that meander through the plains, are more or less charged with earthy particles, worn from the rocks and strata over which the waters flow; and the united streams, in their progress towards the rivers, become more and more loaded with adventitious matter, and a great quantity of detritus is mechanically suspended in the water, and carried towards the sea. If the current is feeble, and the inclination of the ground but slight, a large proportion of the mud, pebbles, and gravel, subsides in the bed of the river; but the greater part is transported to the mouth of the stream, and accumulating in the bays and creeks, and around the embouchure of the river, gives rise to those deposits of alluvial debris termed deltas and estuaries. But the finest particles of the detritus are carried far out to sea, by the currents, and finally sink down, and form layers of mud in the profound depths of the ocean. Rivers, however, convey not only the inorganic materials of the countries through which they flow, but also the leaves, branches, and trunks of trees, and other vegetable remains, and the carcases of land animals that fall into the streams, and terrestrial, lacustrine, and fluviatile shells. The remains of man and works of art are also occasionally transported to the delta, and engulfed in the mud, silt, and sand; and relics of this kind are sometimes drifted out to sea, and deposited in the bed of the ocean.

In the rivers of India and of America these operations are in daily progress on an immense scale. In the Mississippi rafts formed of prostrate forests are transported to the delta of that mighty stream, and become buried in the freshwater deposits which are there rapidly accumulating. In these sediments the remains of the animals as well as plants of the new world are engulfed.

It is evident that should deposits of this nature become dry land, the naturalist, by an examination of the imbedded organic remains, may with certainty determine the characters of the fauna and flora of the country whence these fluviatile sediments were derived. Thus in the delta of the Thames he would find the bones and antlers of the deer, horse, dog, and other domesticated animals, with the leaves and branches of the elm, oak, ash, and other trees and plants of our Island, with human bones, fragments of pottery and other works of art; while in that of the Ganges or the Nile, the remains of the animals and plants of India or of Egypt would be discovered.*

To apply these data to the elucidation of the present argument. Let us suppose that the river has disappeared, that the sea also has left its place, and that the delta has become dry land; that towns and villages have been built upon the consolidated mud and sand, and that the surface of the country is either covered with woods and forests, or under cultivation. If in natural or artificial sections of these deposits, the bones of men and animals, with works of art, and the remains of plants and river shells, should be found in the clays or sands, such appearances would excite in us no surprise, because we are acquainted with the processes by which the strata were accumulated; and should an inhabitant of the new country express his astonishment how fragile shells, and delicate leaves, and bones of animals became enclosed in the solid rock, and, refusing assent to our interpretation, attribute their presence to the effect of a deluge which softened the crust of the earth, and imbedded in the sediments of its waters the remains of animated nature,—our reply would be that such a catastrophe must inevitably have intermingled the relics of the animals and plants of the land, the rivers, and the ocean, and that the regular stratification of the materials, and the exclusively fluviatile and terrestrial character of the fossil remains, are fatal to such a hypothesis, and confirmatory of our explanation of the phenomena. It was by such a train of reasoning that the fluviatile origin of the Wealden deposits was established.

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* For a more extended view of this subject, see "Wonders of Geology," vol. i. p. 42.

The strata composing the Wealden formation of the south-east of England admit of the subdivisions given in the tabular arrangement, p. 42. Alternating layers of clays, sands, and limestones almost wholly composed of freshwater univalves, and of small bivalves with minute crustaceans, form the upper series. Sand and sandstones, with bands of arenaceous limestones or calciferous grits, with shells and lignite, prevail in the middle group; while in the lowermost, sands, clays, and argillaceous shelly limestones again appear; and buried beneath the whole is a petrified forest of pine-trees with cycadeous plants, still erect in the soil in which they grew; and in all these deposits bones of colossal terrestrial reptiles are more or less abundant. The upper clays and limestones occupy the valleys of the Wealden districts that skirt the inner escarpments of the chalk downs in Surrey, Kent, and Sussex; the middle group of sands and sandstones constitutes the Forest-ridge of those counties; and the lower series appears in the deep valleys in the east of Sussex, around Battel, Brightling, Burwash, and Ashburnham. The Purbeck strata, which are characterised by thick beds of shelly limestone principally formed of a small species of paludina, appear on the coast of Dorsetshire, in the Island, or more properly the Peninsula, whence the name is derived. The Wealden presents the most perfect example of an ancient delta hitherto discovered: in the numerous formations comprised in the systems of geology, there is no other instance of so well defined and extensive a group of fluviatile deposits.*

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* Scarcely twenty-five years ago, though the Wealden districts were traversed daily by hundreds of intelligent persons in their journeyings to and from London and Brighton, their freshwater origin was unsuspected; the whole group being considered by geologists as identical with the sands, clays, &c., of the chalk formation. For though the shells forming the Sussex marble of the Weald clay were supposed, so long since as Woodward's time, to be fluviatile species, yet this point was controverted by some able conchologists; and but few, if any other, organic remains had been obtained from the strata of the Weald. Having, for several years, diligently collected the fossils of the south-east of Sussex, and separately arranged the specimens from different localities, I was struck with the want of accordance between the organic remains from the chalk, galt, firestone, &c., and those which I had obtained from the quarries and wells, opened or sunk in the Wealden district, and by degrees, the freshwater character of the area between the greensands of Sussex, Kent, and Surrey became manifest. The absence of ammonites, echinites, terebratulæ, corals, and other common and characteristic fossils of the chalk, in my Wealden collection, was a circumstance that could not fail to arrest attention; and the discovery of the bones of large reptiles,

The total thickness of the Wealden (inclusive of the Purbeck beds) is estimated at upwards of 1,500 feet, being equal to three times that of the delta of the Mississippi.*

WEALDEN STRATA OF THE ISLE OF WIGHT.—In the Isle of Wight but a small portion of the upper series of clays, sands, and sandstones is exposed to view. These deposits constitute the line of coast already noticed, in Sandown Bay, and the range of cliffs from near Atherfield Point to Compton Bay. The section exposed in the cliffs on the south-western coast, is shown in lign. 16 (p. 157), from Dr. Fitton's Memoir; to which reference must be made for details, which, though of great value in a scientific point of view, possess but little interest for the general observer.† The Wealden strata forming this line of coast consist of laminated clays, shales, and loosely coherent sands, full of freshwater shells and crustaceans, with lignite, and in some strata abundance of pyrites; layers, a few inches in thickness, of tough bluish argillaceous shelly limestones, some being composed chiefly of bivalves, and

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with the leaves and stems of ferns, cycadeous plants, &c., in the strata of Tilgate Forest, of which there were not the slightest traces in the cretaceous deposits, corroborated the inferences suggested by my previous observations. In 1822 the Tilgate strata were first described, and their freshwater origin pointed out in "The Fossils of the South Downs." In June, 1822, I communicated to the Geological Society of London an account of the extension of these strata over Sussex, being the result of my own and Mr. Lyell's observations. In 1827, "The fossils of Tilgate Forest," containing nearly 200 figures of Wealden fossils, was published. See Dr. Fitton's charming little work—"A Geological Sketch of the Vicinity of Hastings." London, 1832. P. 13.

* The delta of the Mississippi is computed by Mr. Lyell to be 528 feet, or about the tenth of a mile in depth; the area it covers, 13,600 square statute miles; the solid matter annually added, 3 billions 700 millions cubic feet; and the period required for its formation, many thousand years.

† "Geol. Trans." vol. iv. second series, p. 197—220.

others of univalves; sands, with concretionary nodules of calcareous compact grit and sand-rock; and variegated clays, mottled with different shades of red, yellow, blue, green, and grey; waterworn bones of reptiles occur throughout. But the subdivisions of the Wealden are in a great measure arbitrary, for the same fossils and the same lithological characters pervade the entire series. Beds of sands, clays, and argillaceous limestones, and calciferous grits, almost identical in mineral composition, and containing similar organic remains, are found alike in the upper and lower part of the series; indicating a similar condition of the land and water throughout the Wealden epoch. In that part of Sussex over which my earliest researches extended, the univalve limestones (Sussex marble) and shales predominate in the upper series; sands and calciferous grits alternating with clays in the middle; and bivalve limestones and clays in the lower division. But in the Isle of Wight, the clays and limestones with bivalves are as abundant as those with univalves; and slabs from Sandown and Compton Bays could not be distinguished from the shelly limestones of Ashburnham and Battel, in Sussex.*

EXCURSION TO BROOK BAY.—The Wealden strata extend between six and seven miles along the coast; we have already noticed their emergence from beneath the greensand at Atherfield Point (*ante*, p. 163) and at Compton Bay (p. 156). From Compton Chine to Brook Chine, a distance of but little more than two miles and a half, the most interesting phenomena may be examined in a stroll along the beach, which should be undertaken at the ebb of the tide, to allow of sufficient time for the collection of specimens. If a brief visit only be contemplated, the tourist should drive to Brook, and within a short distance of the chine,* and he may alight within a few hundred yards of the most interesting spot—the fossil forest at Brook Point. The most favourable season for a geological examination of this part of the coast is the early spring—the latter end of March or the beginning of April—for at low water a great extent of sand is laid bare, and reefs of Wealden sand-rock are seen stretching far out to sea; and the high tides often sweep away the shingle from the base of the cliffs, and the lowermost visible strata are exposed. The chance of obtaining fossil bones is also greater at this period of the year than at any other, owing to the inroads of the sea on the clay cliffs, and the consequent dislodgment of any bones they may contain; and as these relics are very heavy from an impregnation of pyrites, they fall on the shingle, and are left by the retiring waves.

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* It may be worth inquiry whether the Wealden strata of the Isle of Wight really belong to the upper division—whether they may not be referable to a lower group, and the superior beds have been destroyed by the incursions of the sea, before the delta subsided, and the greensand was deposited upon the now uppermost bed of clay?

We shall commence our ramble at the foot of Compton Chine, near which place fossils of the greensand and of the Wealden alike abound.

CLIFFS FROM COMPTON CHINE TO BROOK POINT.—The description of the coast as seen from the foot of Afton Down, given on our previous visit to Compton Bay (p. 153, Pl. XI.), and a reference to the sections in lign. 16 and 17, p. 157, and to the map (Pl. XX.), will afford the necessary information as to the geological relations of the strata we are about to examine. As we descend to the sea-shore near Compton Chine, the top of the cliff, to the depth of ten or twelve feet, is seen to be composed of drifted gravel, clay, and loam; and this alluvial covering continues for several miles along the coast, forming, as shown in the annexed sketch (Pl. XIV.), a horizontal bed upon the edges of the inclined strata of which the lower part of the cliff consists. In this accumulation of drifted materials are numerous trunks of trees and quantities of hazel-nuts, in the usual condition of peat or bog-wood. The trunks are several feet in length, and a foot or more in diameter; the ligneous substance is very black and soft when first extracted, but hardens after exposure to the air; and some of the wood is so firm in texture as to be employed for various domestic purposes. I could not learn that any bones had been found in this subterranean forest, but I picked up, on a bank hard by, teeth of the horse and deer, which were deeply stained with phosphate of iron, and probably belonged to this alluvial deposit.

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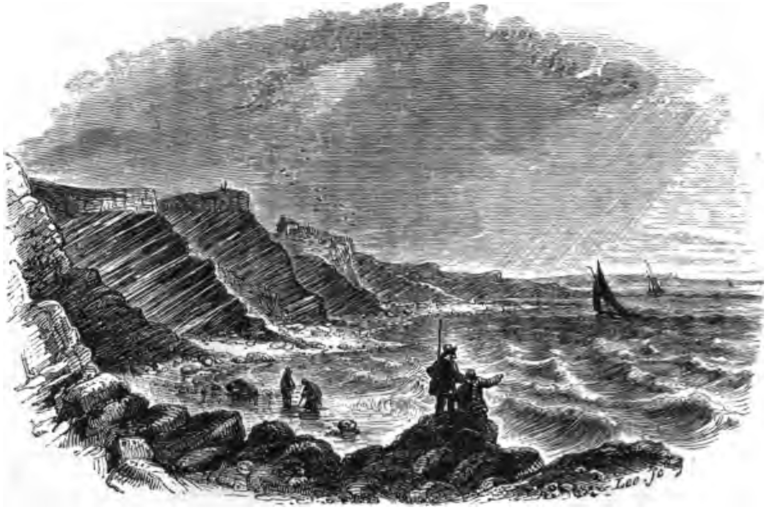
* There is no inn near the spot, but accommodation for horses may be obtained at a neighbouring farm-house or cottage.

The Wealden strata, to the east of their junction with the greensand, principally consist of clays, with seams of shale and sand, and layers of shelly limestone. The appearance of the face of the cliff formed by these strata is shown in Pl. XIV. In this view the nearest headland is Bullface Ledge; that beyond, which extends far out to sea, is Brook Point, the western extremity of the bay; that in the far distance is the eastern boundary of the same. The view of Brook Point from Afton Down (Pl. XI. p. 153,) shows the continuance of the cliffs from beyond Bullface Ledge and Brook Bay to Blackgang Chine.

Masses of the Wealden clay with freshwater shells, in connexion with the greensand containing marine shells, should be the first objects of research. Mr. Morris was so fortunate as to obtain from this spot a mass in which specimens of a very characteristic univalve (*Potamides carbonarius*, Pl. VI. fig. 5) were imbedded. Waterworn blocks of the shelly limestones (Pl. VI. figs. 2, 3, 4), and rolled fragments of bones washed out of the cliffs, will be found in abundance in the shingle. Slabs of the freshwater limestones may be observed in the cliffs at an accessible

Pl. XIV.



CLIFFS OF WEALDEN CLAYS IN COMPTON BAY; SEEN FROM THE WEST.

height; and specimens of the shale, covered with cyprides and shells, may be obtained from the fallen masses on the shore.

The laminated clays and shales are succeeded, as we advance eastward by mottled plastic clays, containing bands of reddish and yellow sand, and hard-grit or sand-rock; and the strata gradually decline till we reach Brook Bay, where they are nearly horizontal.

From Bullface Ledge we perceive the low promontory of Brook Point that forms the eastern boundary of Compton Bay, and at its base a reef of rocks extending seaward to a considerable distance. If the tide is very low, a succession of ledges of this kind are visible along the shore, stretching out to the distance of half a mile or more from the land, and indicating the former extent of the southern coast of the Island, at a comparatively very modern period. These reefs and rocks consist of the harder masses of the Wealden sandstone, which have resisted the destructive effects of the waves, after the clays, sands, and softer materials have been swept away.

Brook Point.—As we approach Brook Point, the variegated sands and grit which lie beneath the clays become more developed; and large waterworn blocks of sandstone appear here and there on the shore. The ledge at the base of the cliff, which formed so prominent a feature of this part of the coast when seen from a distance, consists of indurated sandstone inclosing trunks and branches of large trees completely petrified, many of which are strewn along the strand, and half buried in the sand and shingle. The projecting masses at the foot of the cliff are the broken edges of the strata, and the trunks of fossil trees; the upper and less coherent deposits having been washed away.

The cliff is between thirty and forty feet high, and is capped by the bed of loam and gravel previously noticed at Compton Chine. Beneath this alluvial covering are laminated clays and shales, and sand and friable sandstone, abounding in masses and layers of lignite; and minute particles of the same substance are disseminated throughout the strata. Pyrites occurs abundantly in small nodules and spheroidal masses; and this mineral generally pervades the lignite and wood. Towards the base of the cliff are the beds of sand and sandstone, with hard concretionary grit, containing the fossil trees; and beneath these are seen at low water, compact variegated sands, which are the lowermost deposits in the Island. East of the Point is Brook Chine, a deep fissure or chasm that has been worn in the softer strata by the long continued erosion of a stream, which gushes out from beneath the sand beds inland, and flowing through the alluvial gravel to the top of the cliff, falls in a cascade to the sea-shore.

PETRIFIED TREES.—The prostrate fossil trees at Brook Point were first noticed by Mr. Webster thirty years ago.* After describing the clays and sandstones of the cliff, Mr. Webster states that he "observed many masses of a coaly blackness, bearing the exact form and resemblance of trunks of trees that had been charred, lying on the beach, and imbedded in the clay-cliffs, and also in the rock. In some parts the ligneous fibre was still evident; in others the wood had been converted into a substance much resembling jet, its blackness being intense, its cross fracture conchoidal, and its lustre very great. Other parts of the trees were entirely penetrated by pyrites, and groups of crystals of this substance were frequently attached to the outside. On lifting up some of the sea-weed that grew upon the shore between high and low water-mark, I was astonished to find almost all the rocks below them composed of petrified trees which still retained their original forms. The knotty bark and ligneous fibre were very distinct; and trunks and branches were frequently imbedded in masses of clay now indurated and in the state of argillaceous rock."

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* Sir H. Englefield's "Isle of Wight," p. 153.

Upon first reading the above description, my curiosity was strongly excited, and when in the course of my researches in the strata of the Wealds of Sussex, the fluviatile origin of those deposits became evident, I felt an irresistible desire to visit Brook Point, in the expectation of beholding a petrified forest of the country that had been inhabited by the colossal reptiles, of which so many remains had been discovered in Tilgate Forest. Nor was my expectation disappointed; I have visited this coast many times, and always with increased interest—an interest which I hope to excite in some of my intelligent readers, and induce them to repair to the spot, and investigate the phenomena, of which these pages can present but a feeble outline.* The trees are all lying prostrate and confusedly intermingled. There are no erect trunks, nor any other indications that the forest was submerged with its native soil, like that of the Isle of Portland.† On the contrary, this accumulation of fossil trees resembles the rafts, as they are termed, that are annually brought down from the interior of the country by the tributary streams of the great rivers of North America, and which, hurried along by those vast floods, entangle in their course the remains of animals and plants that may happen to lie in the beds of the rivers, or be floating in the waters. These rafts are at length drifted out of the course of the currents, and becoming loaded with mud, sand, and other extraneous matter, sink down, and are engulfed in the bed of the delta.*

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* In June 1823, my friend, Mr. Lyell, visited Compton Bay for the purpose of ascertaining more clearly the relations between the ironsand of Mr. Webster and the strata of Tilgate Forest, of which an account had appeared in my "Fossils of the South Downs." In a letter detailing the result of his investigation, Mr. Lyell remarks:—"At Compton Chine, I found in Webster's blue marl several small Inocerami (*I. sulcatus*), and some other characteristic shells, so that I believe the identity of this bed with the Folkestone galt might be made out by further research. The section from Compton Chine to Brook is superb. We see there at one view the whole geology of your district, from the chalk with flints down to the battel beds, and all within an hour's walk.—This is so beautiful a key, that I am at a loss to conceive how so much confusion has arisen.—The softness of the Weald clay has caused a ruinous state of the cliff just where the Sussex marble ought to be. Soon after this, layers of limestone with bivalves appear; then some mottled beds; then pyritous coal (lignite) like that at Bexhill, I presume.—In Sandown Bay I picked up a block of Petworth marble two feet in diameter, of which, and the other rocks, I will send you specimens."

† "Wonders of Geology," vol. i. p. 362.

The fossil trees at Brook Point appear to have been submerged when arrived at maturity, and while fresh and vigorous; for the trunks before removed from the sandstone, are invariably covered by the bark in the state of lignite. This cortical investment quickly disappears when the stems are exposed to the action of the waves; but the ligneous structure, which is converted into a very hard calcareous stone, for a long while resists destruction. Trunks and branches, from a few inches to three feet in diameter, and many feet in length, are in general to be seen lying on the shore between high and low water-mark; and in these specimens the texture of the wood, and the annular lines of growth on the waterworn transverse fractures, are strongly defined. On a late visit there were two stems which could be traced to a length of twenty feet; and they were of such a magnitude as to indicate the height of the trees when living at from forty to fifty feet. Many stems are concealed and protected by the fuci, corallines, and zoophytes, which here thrive luxuriantly, and occupy the place of the lichens and other parasitical plants, with which the now petrified trees were doubtless invested when flourishing in their native forests, and affording shelter to the Iguanodon and other gigantic reptiles.

STRUCTURE OF THE FOSSIL WOOD.—These fossil trees are calcareous, not siliceous like those of Portland. The wood is more or less traversed by veins and filaments of pyrites, which impart a beautiful appearance to polished specimens of the stems. Slices rendered transparent by Canada balsam, exhibit under the microscope, in the transverse sections, the cellular tissue as a reticulation of polygonal meshes; and in the radial, the ducts or glands characteristic of the coniferæ, and arranged in alternate rows as in the araucaria or Norfolk Island Pine.* The annular lines of growth are often very distinct; I have traced from thirty to forty on some of the stems. These circles are of unequal thickness, and therefore indicate a variation from year to year in the climate of the country in which they grew. They are, too, as small as in the slow growing pines and firs of England. Many of the stems exhibit an obliquity in the annular lines, proving that they grew in situations which exposed the trees to prevailing currents of wind from a particular quarter, and caused them to incline in the opposite direction. I have discovered no vestiges either of the foliage or fruit. It is remarkable that coniferous wood occurs but sparingly, if at all, in the Wealden deposits of the south-east of England; but drifted stems and branches of pines of the araucarian type, are common in some of the upper beds of the greensand, and are occasionally met with in chalk flints.†

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* "Wonders of Geology," vol. ii. p. 667.

Such is a brief description of the accumulation of fossil trees at Brook Point, which evidently originated in a raft composed of a prostrate pine-forest, transported from a distance by the river which flowed through the country whence the Wealden deposits were derived, and became submerged in the sand and mud of the delta, burying with it the bones of reptiles, mussel-shells, and other extraneous bodies it had gathered in its course.

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* See "Medals of Creation," vol. i. p. 71.

† "Medals," vol. i. p. 168.

In the strata that overlie the fossil forest, thin interrupted seams of lignite,* and masses of the same substance invested with crystals of brilliant pyrites, are every where abundant; and beautiful and instructive specimens may be obtained.† In the clays for several hundred yards both to the east and west of Brook Point, bones of the Wealden reptiles are numerous; with these are associated large mussel-shells (Pl. VI. fig. 1), and lignite. To the east of Brook Bay is Brixton Bay; and along this line of coast, as far as Atherfield, similar organic remains are continually met with after the high tides of the early spring. I have not examined the cliffs further to the eastward, and must refer to Dr. Fitton's Memoir for a particular enumeration of every important stratum, along the southern coast of the Isle of Wight. My attention has always been so much engrossed by the interesting phenomena observable in Brook Bay, which is at all times easy of access, that I have had neither leisure nor inclination to extend my researches to the east of the point above mentioned. Dr. Fitton states that in the cliff at "*Tiepit*, and thence to *Shepherd's Chine*, and within that chine and *Cowlease Chine*, the Wealden clay and its passage to the sands beneath, are better displayed than in any other localities."‡

* LIGNITE, &c.—For an account of the changes by which vegetable substances are converted into lignite, coal, &c., see "Medals of Creation," vol. i. chap. 5.

† Unfortunately these specimens generally fall to pieces after a few months, in consequence of the decomposition of the pyrites with which they are permeated.

‡ "Geol. Trans." vol. iv. p. 198.

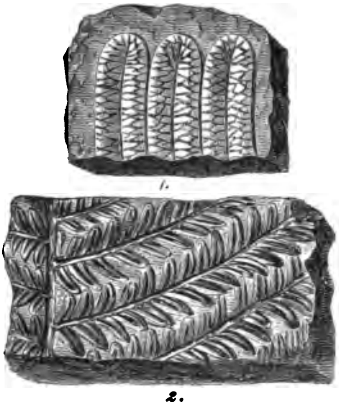
CHAPTER X.

ORGANIC REMAINS OF THE WEALDEN—FOSSIL VEGETABLES—ENDOGENITES EROSA—CYCADEOUS PLANTS—CLATHRARIA LYELLII—FOSSIL SHELLS—UNIO VALDENSIS—FOSSIL CYPRIDES—FOSSIL FISHES.

Fossils of the Wealden.—The Wealden strata of the Isle of Wight have afforded examples of the most characteristic organic remains that have been discovered in this formation in other parts of England. They have yielded five or more genera of terrestrial plants; of which one belongs to the Pines, several to the Cycadeæ, and two or three to the Ferns: several species of river-shells, of the genera Unio, Paludina, Potamides, Cyclas, &c.; and of the small crustaceans, the Cyprides. Fishes allied to the Bony-pike and the Sharks occur, and bones of seven or eight species of terrestrial saurian reptiles, and of two or three genera of Chelonians.

Fossil Vegetables.—Our description of the fossil forest of Brook Point entered so fully into the character of the coniferous trees of the Wealden, that it is unnecessary to enlarge upon that subject. A great proportion of the lignite in the laminated sands and clays forming those cliffs, is undoubtedly the bark of the mature trees, and the wood of the young plants, in a carbonized state.

But the coaly particles disseminated through the strata have probably, in a great measure, originated from the foliage of two elegant extinct species of ferns, that abound in some parts of the Wealden of Sussex, and of which a few recognisable specimens have been discovered in the Isle of Wight.



LIGN. 21.—A FOSSIL FERN (*Lonchopteris Mantelli*) FROM THE WEALD CLAY; BROOK POINT.

Fig. 1.—Portion of three leaflets, magnified, to show the reticulations of the veins.
2.—Part of a stem, with leaves.

Fossil Ferns.—Entire layers of the sandstone, grit, and shale, in Tilgate Forest, are so full of carbonaceous matter as to acquire a dark mottled colour, and this detritus is composed of minute particles of the leaves and stems of ferns, that have been ground to pieces by agitation in water loaded with sand and mud. One of these plants (*Sphenopteris Mantelli*, "Wonders of Geology," p. 370) is characterised by its slender wedge-shaped leaflets. The other fern (*Lonchopteris Mantelli*, lign. 21) is the species already mentioned as occurring in the greensand of Atherfield and Shanklin. It is distinguished by its long and many-times pinnated leaves, and the reticulated disposition of the secondary veins that spring from the mid-rib of the leaflets.

Endogenites erosa.—In the strata of Tilgate Forest, and in the sands at Hastings, numerous fragments of the stems of a remarkable monocotyledonous (?) plant occur, and are mentioned in my Fossils of the South Downs, and figured in the Fossils of Tilgate Forest, &c. These stems are of various forms; some are cylindrical, and tapering at both ends; and others are flattened, and of a clavated shape, like some of the *Cacti* and *Euphorbia;* the specimens are from a few inches to seven or eight feet long, and the largest from twenty to thirty inches in circumference. When imbedded in the strata, a thick coat of lignite surrounds the stem; but this soon becomes friable, and falls off after exposure to the air. The constituent substance of the stems is a grey, compact, subcrystalline sandstone, and the external surface is traversed by fine semicircular grooves and deep tubular furrows, lined with minute quartz crystals; a transverse section exhibits the surface covered by small pores, and a few large openings, the sections of the tubes. From the eroded appearance of the surface of the specimens, when deprived of their carbonaceous investment, the name *Endogenites erosa,* was given to this fossil plant by Messrs. Stokes and Webb, who described it from my specimens, in the "Geological Transactions," vol. i., second series. Dr. Fitton* subsequently described and figured a series of interesting specimens observed by him in the strata at Hastings. In transverse slices of these fossils, obscure indications of circular bundles of vascular tissue were detected, but (as in all my specimens from Tilgate Forest) very few vestiges of organic structure were apparent; the cavities exposed in the sections being not the vessels themselves, but the hollows left by their decay.† The occurrence of this fossil plant in the Wealden of the Isle of Wight has only recently been discovered. Among the waterworn fossils which I collected from the shingle, on my last visit to Brook Point, was a rounded, sub-cylindrical block of sandstone, very smooth, and marked externally with small crescent-shaped spots, which are the terminations of bundles of vascular tissue.

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* "Geol. Trans." vol. iv. p. 172.

† Dr. Fitton has given magnified figures of the sections in his pl. xx.

A transverse section of this fossil proved it to be a portion of the stem of the *Endogenites erosa*, in a better state of preservation than any example previously obtained. The openings, instead of being empty, are for the most part occupied by the vessels; and an external band, or zone, of vascular tissue, disposed somewhat in festoons, is tolerably well preserved. Very thin slices, immersed in Canada balsam, to render them as transparent as the dull siliceous substance of which they are composed will admit of, examined under the microscope, indicate, in the opinion of Dr. Robert Brown, a nearer approach to the cycadeæ than to the endogenous tribes.

FOSSIL CYCADEOUS PLANTS.—Among the coniferæ, or cone-bearing plants, the *Cycadeæ* and *Zamiæ* are remarkably distinguished by the peculiarity of their fructification, their seeds being exposed; hence the name of the order in which these plants are arranged—*gymnospermous*, *i.e.*, naked seeds. The organisation of their stems is also different from that of the other coniferæ.* As several species of zamia and cycas are cultivated in our greenhouses, their general aspect, which approaches that of the palms, must be familiar to the reader. Most of the zamiæ are short plants, with stout cylindrical stems, beset with thick scales, which are the petioles, or leaf stalks, left after the leaves have fallen off. On the summit of the stem is a crown of elegant pinnated leaves, with simple veins. The fruit bears some resemblance to the cones of the pines, but the seeds are not enclosed in receptacles. The cycadeæ resemble the zamiæ, but the trunk is in general longer; one species, *Cycas circinnalis*, attains a height of thirty feet. The stem is in most species simple, but in some it is dichotomous, dividing into two or more branches; the leaves are tough, and in the young state coiled up like a crosier, as in the ferns. These plants are inhabitants of hot and humid climates, and abound in the West Indies, Molucca Isles, &c. A few plants of this order have been detected in the carboniferous strata; and in the lias and oolite they appear in immense numbers; several species have been found in the Wealden and cretaceous formations. The discovery of cones of a species of zamia (*Z. crassa*, "Medals of Creation," p. 160), associated with bones of the iguanodon, in the Wealden strata in Sandown Bay, has already been mentioned (p. 99).

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* See Dr. Buckland's "Bridgwater Essay," p. 490.

CLATHRARIA LYELLII.—But the most interesting fossil plant belonging to this tribe of coniferæ, of which any remains have been found in the Wealden, is that discovered by me in Sussex, and described in 1822; and subsequently in "The Fossils of Tilgate Forest," under the name of *Clathraria Lyellii.*[*]

This plant was formerly classed with the *Liliaceæ,* by that eminent botanist M. Adolphe Brongniart; but the discovery of more illustrative specimens than those first obtained, indicate its affinity to the cycadeæ, with which M. Brongniart has some years since arranged it. The stem of the clathraria[†] is composed of an axis having the surface covered with reticulated fibres, and of a false bark produced by the union of the consolidated bases of the petioles, the insertions of which are rhomboidal and transverse. The external surface of the stem is in consequence covered with lozenge-shaped elevated scars, separated by lateral depressions, which are surrounded by a parallel band of a fibrous appearance (see lign. 22). This outer portion is sometimes consolidated into a compact cylinder of stone, which will separate from the central axis ("Fossils of Tilgate Forest," Pl. II.): the latter is solid, and strongly marked externally with reticulated interrupted ridges. This surface has generally patches of vascular tissue adhering to it, but these are in so friable a condition, that microscopical examination has thrown no light upon their structure.* On some parts of the internal axis there are deep pits, indicating the lacunæ in which a resinous secretion was contained.

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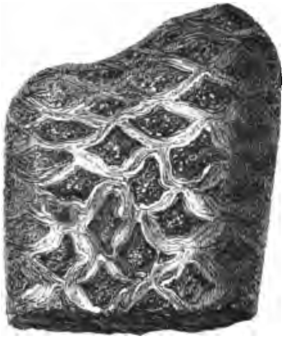
[*] "Fossils of Tilgate Forest," Plates I. II. III., and "Geology of the South-East of England," Pl. I.

[†] *Clathraria,* or latticed stem; so named from the scorings left on the stem by the attachment of the petioles.



LIGN. 22.—WATERWORN STEM OF THE CLATHRARIA LYELLII.
From the Shingle in Brook Bay.
(One-third linear, nat. size.)

The waterworn portion of a stem, figured in lign. 22, which I picked up on the sea-beach in Brook Bay, is the only specimen of the Clathraria I have seen from the Wealden of the Isle of Wight. This fragment is highly interesting, for the calcareo-siliceous earth, of which the stem now consists, is of a finer texture than in any of the Tilgate Forest specimens, and transverse sections display under the microscope, more satisfactory indications of the organisation of the original. Without many figures, and more lengthened descriptions than our space will admit of, the peculiarities of structure exhibited in these slices could not be demonstrated; it must therefore suffice to state, that the organisation, so far as it can be determined, shows a near approach to that of the cycadeæ.

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* For other details I must refer to the "Medals of Creation," vol. i. p. 182. All the specimens figured in my previous works are in the British Musuem, in the room appropriated to fossil vegetables.

But additional and most important information as to the external form of the clathraria, has been afforded by the splendid specimen from the chalk marl of the Undercliff, mentioned in a previous chapter (Chap. VIII. p. 178), as having been discovered by Captain Ibbetson, and now exhibited in his collection of Isle of Wight fossils, in the Polytechnic Institution. This invaluable relic is admirably represented by Mr. Dinkel,* and engraved by Mr. Lee, in lign. 23, p. 217.

This specimen consists of the summit of the stem, and is fifteen inches in length; the appearance of the lower end shows that some portion has been broken off and lost. The stem is compressed into an elliptical form; the figure exhibits the longest diameter, and the side on which the characters of the plant are best preserved. On the upper 10½ inches, this trunk is covered by the petioles or leaf-stalks; and these appendages remain on one side almost to the lower extremity. The surface of the inferior portion, to the extent of four inches, is marked with transverse lozenge-shaped scars, produced by the separation of the petioles; the internal axis appears at the fractured end: see lign. 23, *a*. The leaf-stalks are from one to two inches wide, rounded above, and contracted below, as shown in the detached petiole figured in lign. 24; they are traversed by fine and nearly parallel longitudinal veins. The

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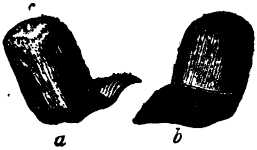
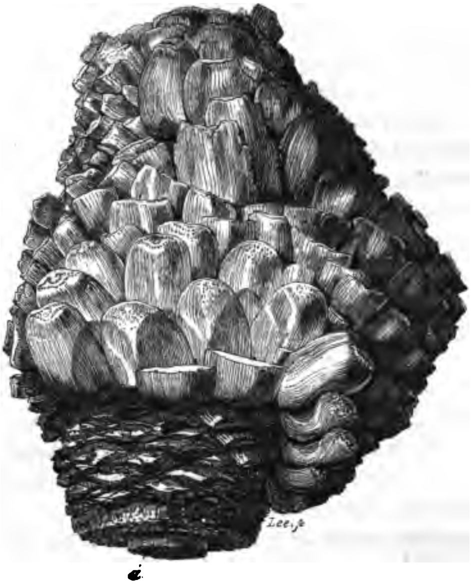
* This eminent artist now permanently resides in London, being engaged at the British Museum by Dr. Falconer, on the illustrations for the important work on the sub-Himalayan Fossils, which is now in progress of publication. For subjects requiring talent, accuracy, and knowledge of animal and vegetable organisation, for their successful delineation, the pencil of Mr. Dinkel will be found invaluable.



LIGN. 24.—A PETIOLE OF CLATHRARIA LYELLII, SEPARATED FROM THE STEM.

a, the external aspect;
b, the internal surface;
c, the vascular markings left on the summit of the petiole by the separation of the leaf.

summits of those petioles from which the leaves appear to have been shed, not broken off, are marked by vascular pits disposed with great regularity, as shown at *c*, lign. 24; a structure which M. Adolphe Brongniart informs me partakes more of the character of the Ferns, than of the cycadeæ. The substance of this fossil is a sandy marl, and probably does not retain any traces of the internal structure of the original; still it is desirable that sections of the petioles and of the stem should be microscopically examined. M. Adolphe Brongniart, to whom I transmitted a sketch of this specimen of the natural size, immediately favoured me with his remarks on this interesting fossil. He considers the specimen to be the upper termination of a stem of the clathraria, garnished with persistent leaf-stalks; and that some of the uppermost petioles were broken off accidentally while the leaves were alive; but that in the lower ones, which possess vascular markings on their summits, the leaves were detached naturally, and these petioles remained, probably for some years, as is the case in the existing cycadeæ. The petioles having fallen from the exposed part of the stem, the surface is left bare, and is marked by lozenge-shaped cicatrices or scars, which are the points of attachment of the bases of the leaf-stalks.



LIGN. 23.—CLATHRARIA LYELLII.

From the chalk-marl at Bonchurch, Isle of Wight; discovered by
CAPTAIN IBBETSON.

This fossil is the summit of a stem garnished with petioles or leaf-stalks on the upper part: from the lower portion the petioles have been removed. The internal axis is seen at *a*. The original is fifteen inches in length, and eleven and a half in the widest transverse diameter.

On the other side of the specimen there appeared to me indications of the foliage, but M. Brongniart suggests it as more probable that they are only elongated and flattened petioles.

The occurrence of this very characteristic plant of the Wealden high up in the chalk formation, is in accordance with the discovery of the bones of the iguanodon in the greensand of Kent.* In the strata of Tilgate Forest the remains of the clathrariæ are invariably associated with water-worn bones of reptiles, and pebbles, gravel, and other drift, and are often imbedded in the fluviatile conglomerate which occurs in some parts of the Wealden.† They appear to have floated down the river with the carcases and limbs of the reptiles, and at length to have sunk to the bottom, and become imbedded in the mud and sand of the delta.

FOSSIL SHELLS.—The shells of the Wealden of the Isle of Wight belong to the same genera and species of fluviatile mollusca as those in the contemporaneous deposits of the south-east of England; and though spread over areas of considerable extent, and through deposits of great thickness, they comprise but a few species—a characteristic feature of the fauna of all rivers. The substance of the shells in the limestones is, for the most part, changed into carbonate of lime; but the shells in the argillaceous strata are often but little altered, and sometimes occur in as perfect a state as in very recent deposits; the epidermis and even the horny ligament being preserved. In the coarse limestones the shells have generally perished, and casts only remain.

SUSSEX AND PETWORTH MARBLE.—The most abundant univalve shells are four or five kinds of *Paludina*; a common river snail, of which there are species in the tertiary freshwater strata of Headon Hill and Calbourne. (See Pl. I. fig. 6.) Numerous beds of marble, coarse limestone, clays, and shales, abound in or are wholly made up of paludinæ and minute crustaceans. The compact Sussex limestone, which, from its taking a good polish, is called marble, principally consists of the shells of one large species, the *Paludina fluviorum* (Pl. VI. fig. 3), held together by an infiltration of crystallised carbonate of lime; the cavities of the shells, and the interstices between them, being often filled with white calc-spar. Upon examining thin slices of this marble under the microscope, the shells are found to contain myriads of the cases of *Cyprides* (lign. 25). The Purbeck marble differs from the above in being composed of a much smaller species—the *Paludina elongata*. (Pl. VI. fig. 2.)

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* "Wonders of Geology," vol. i. p. 394.

† See remarks on the "Discovery of the Hylæosaurus," in "Wonders of Geology," vol. i. p. 401.

These marbles were in great repute with the architects of the middle ages, and there are but few of our cathedrals and ancient churches which do not still contain examples of both varieties, either in their columns, sepulchral monuments, or pavements. The polished cluster-columns of the Temple Church in London, and many of the monuments in Westminster Abbey, are of Purbeck marble; in other words, they are composed of the petrified shells of snails, that lived and died in the rivers which flowed through the country inhabited by the extinct colossal reptiles. The dark masses and veins so common in these marbles, are the remains of the bodies of the mollusca, changed into the carbonaceous substance termed *molluskite*. (See *ante*, p. 181.) The shells which were empty at the period of their becoming imbedded, had their cavities filled with the mud, silt, &c., which are now clay, marl, and limestone; but in the shells containing the animals, the gelatinous parts were converted into molluskite. In polished sections of the marbles this substance appears either within the shells, or in black or dark brown masses and veins. The most beautiful slabs of Sussex marble owe their variegated markings to the contrast produced by the black molluskite with the white calcareous spar.

Potamides.—Some species of the elongated, spiral, freshwater univalves, termed *Potamides*, of which several occur in profusion in the strata at Headon Hill (see Pl. II. figs. 2, 8, 9), are found in the Wealden. A very characteristic shell, the *Potamides carbonarius*, is figured in Pl. VI. fig. 5. This species was first discovered in the Weald clay at Pounceford in Sussex.* It also occurs in Hanover, in the clays intercalated with beds of coal, belonging to the Wealden formation.

FOSSIL FRESHWATER BIVALVES.—Many of the bluish grey argillaceous limestones, as we have before remarked, are chiefly composed of five or six species of bivalves of the genera *Cyclas* and *Cyrena*; a small slab, with several shells in relief, is represented Pl. VI. fig. 4. Large blocks covered with shells of this kind are commonly to be found along the base of the cliffs, at Brook, Compton, and Sandown bays; and in the clays there are numerous seams of crushed shells of these genera. The hard grits often abound in casts of cyclades, associated with a small species of river-mussel (*Unio*); and some layers of Sussex marble contain an intermixture of these shells with the paludinæ.

UNIO VALDENSIS. Pl. VI. fig. 1.—The only other bivalves which occur in any considerable number in the Wealden, are the mussels termed *Unionidæ*—a family of testaceous mollusca containing several genera, and comprising many species of considerable magnitude. These animals have a solid pearly shell, with two principal and two lateral teeth on the hinge. In number, variety, and internal lustre, the uniones of the large rivers of North America present a striking contrast with the few and homely British species. In a fossil state uniones are rare; a few occur in the carboniferous strata, and these, with eight or nine small species from the Wealden, figured by Dr. Fitton and myself, comprise all that are known in our secondary strata.

* "Wonders of Geology," p. 350; it is there named *Melanopsis*.

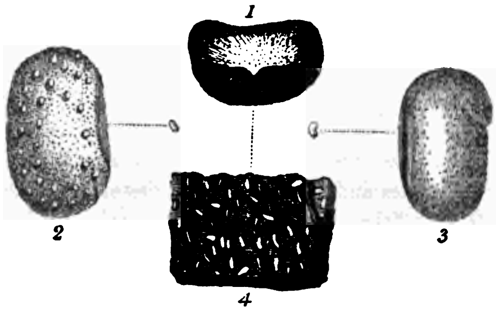
Many of the slabs of limestone procured from Sandown Bay, and used in the pavements at Brading, Ryde, &c., display sections of a species of unio, which is common in some of the Petworth and Purbeck beds. On a visit to Brook Point in 1843, I discovered a remarkably fine and large species of unio in the cliff above the petrified trees, and have since collected many specimens of this interesting fossil, which I have proposed to distinguish by the name of *Unio Valdensis*, or Wealden river-mussel. A small and young example is figured in Pl. VI. fig. 1; the hinge and the anterior muscular imprints are shown in the upper figure. The specimens obtained from the cliffs are in an excellent state of preservation; the surface of the shell, which is but little worn, is of a tawny-red colour, like some of the recent Ohio species. Even the horny ligament with its transverse rugæ remains; and in some instances the shell is occupied by the body of the animal in the state of molluskite. The constituent substance of the shell is occasionally changed into calcareous spar, and admits of a fine polish. Nodules of crystallised sulphate of barytes of a pink colour, are not uncommon within the shells. Some examples which I extracted from the bed containing the fossil trees, are partially invested with lignite. One pair of valves has been separated, and the hard grit with which they were filled cleared away, so as to develop the characters of the hinge, &c.

The shell is of an ovate form, from four to six inches long, three inches in altitude, and two inches in thickness or diameter; the weight of a pair of valves cleared from extraneous matter is eleven ounces. The shell is equivalved, sub-equilateral, the posterior half one-fifth longer than the anterior, and compressed along the margin of the anterior slope. It is very thick and strong, and marked externally with longitudinal striæ. The summit is rounded, antero-dorsal, and slightly inclined forward; the umbones are decorticated, as in most of the shells of the Unionidæ. The ligament is external, post-apicial, and marked with transverse rugæ.

The base or circumference of the shell is entire; the margin or internal lip is thick and flat. The inner surface is smooth, with the exception of a few irregular projections of nacreous deposit. The hinge is dorsal, the hinge-plate very thick, with a deep fosse beneath the lamellar portion. The cardinal teeth of the right valve are two; the anterior one is the largest, and bifurcated; the lamellar tooth-plate is broad. The anterior muscular imprint is in front of the large cardinal tooth, and immediately behind this impression is the indentation left by the attachment of the retractor muscles of the foot. The posterior muscular imprint is placed at the extremity of the lamellar tooth-plate. The palleal impression extends from one muscular imprint to the other, running parallel with the margin of the base. There is a considerable difference observable in the width of the posterior part of the shell in a series of specimens, which appears to be sexual; for a similar variation occurs in the male and female shells of the recent species from the Ohio.

The collocation of these large mussels with drifted trees and bones of land reptiles, in clays and sands so manifestly of fluviatile origin, completes the analogy between the rafts imbedded in the delta of the Wealden, and those which float down, and become engulfed in the mud and silt of the Mississippi.

Fossil Cyprides.—The minute crustaceous animals termed *Cyprides*, of which the shells or cases of several species are so abundant in the Wealden strata, were brought under the notice of the reader in our examination of the tertiary strata at Whitecliff Bay and Headon Hill; and in the clays and shales of Sandown Bay (p. 98). These animals have the body enclosed in a horny case, consisting of two pieces united by a hinge line. They have one compound eye, and four feet, and two straight simple antennæ with a tuft of cilia at the extremities. They swim with rapidity, and may be seen actively pursuing the minuter animals on which they prey. Like other crustaceans, they frequently shed their cases, and the surface of the mud spread over the bottom of still lakes is covered with their exuviæ. The largest living cypris does not exceed one-sixth of an inch in length. In a fossil state these cases appear like minute, white, elliptical, or reniform scales, on the surfaces of the recently separated laminæ of clay, shale, and limestone. After exposure to the weather the cases decompose, and leave the surface of the stone covered with their casts, which appear as minute polished tubercles; some layers of the compact ironstone have a granulated appearance from the abundance of these remains. Three species of the Wealden cyprides are represented in lign. 25.



LIGN. 25.—FOSSIL CYPRIDES; FROM BROOK BAY.

Fig. 1. *Cypris spinigera;* the small figure shows the natural size.
2. *Cypris granulosa.*
3. *Cypris Valdensis.*
4. Clay, with numerous cases of the species represented fig. 1, of the natural size.

The immense accumulation of the remains of these crustaceans in the Sussex marble is quite surprising; some slabs which I have examined under the microscope, have the shells and their interstices literally crammed with whole and broken cases. As the recent species inhabit either still lakes or gently flowing streams, and not the turbulent waters of estuaries, it follows that sediments largely charged with the exuviæ of cyprides must have been deposited in lakes, or bays, or in tranquil streams, communicating with the flood of waters which transported to their present situation the bones of terrestrial animals and plants. These beds of fluviatile shells and cyprides, with scarcely any intermixture of other organic remains, which are spread over such wide areas of the Wealden formation, afford, therefore, decisive proofs of tranquil subsidence in fresh-water.

FOSSIL FISHES.—But few remains of fishes have been found in the Wealden of the Island; those which have come under my notice are some small teeth, and a fin-bone, of a species of *Hybodus* (see p. 170); and several teeth and scales of the *Lepidotus*, a genus of extinct freshwater fishes, with very thick, enamelled, rhomboidal scales, and obtuse hemispherical teeth; the latter are called fishes' eyes by the peasants who collect fossils from these shores.* Detached scales and teeth of two species of Lepidotus occur in most localities of the Wealden deposits.† I found a portion of an intermaxillary bone with several teeth, and a group of ten scales of the *Lepidotus Fittoni*, in the cliff to the east of Brook Chine.

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* Figures of the scales and teeth of one species of Lepidotus of the Wealden are given in "Medals of Creation," p. 438, Pl. VI., fig. 10.

† It is rare to meet with any considerable number of scales in contact; but a few specimens were discovered in Tilgate Forest, exhibiting part of the cranium, the opercula of the gills, the pectoral and dorsal fins, and large masses of scales. These are now in the British Museum, in the room appropriated to fossil fishes.

CHAPTER XI.

FOSSIL BONES OF REPTILES—THE IGUANODON—HYLÆOSAURUS—MEGALOSAURUS—CETIOSAURUS—STREPTOSPONDYLUS—PLESIOSAURUS—TURTLES—IMPRINTS ON SANDSTONE—RIPPLE-MARKS—SUMMARY—THE COUNTRY OF THE IGUANODON—VOYAGE ROUND THE ISLE OF WIGHT.

Fossil Bones of Reptiles.—The occurrence of bones and teeth of gigantic terrestrial reptiles in the beds beneath the chalk of the south-east of England, was first announced in the "Fossils of the South Downs," in which many remains of oviparous quadrupeds from the strata of Tilgate Forest are described. Relics of this kind have subsequently been discovered in numerous localities of the Wealden, and nowhere more abundantly than in the Isle of Wight; although search for these highly interesting remains has not hitherto been very actively or judiciously pursued.

The bones are washed out of the cliffs by the inroads of the sea, and strewn on the shore, where they become exposed to the action of the waves, and are soon abraded and deprived of any processes, or other anatomical characters, they may have retained after their original exposure to attrition in the river by which they were transported and imbedded in the strata. Thus those parts which would afford the most valuable information to the anatomist become entirely defaced, and the specimens are for the most part waterworn masses of bone, indicating only the enormous magnitude of the animals to which they belonged. The bones, even when imbedded in the sandstone and sand, are in general abraded, from having been transported by water from a considerable distance; those in the clays are commonly less injured, from the plastic material with which they were enveloped having, apparently, afforded some protection. The bones are coloured and strongly impregnated with iron; especially those in Brook Bay, which are permeated throughout with pyrites; groups of brilliant crystals of this mineral often invest the outer surface. The medullary cavities are occasionally found lined with white calcareous spar, and the cancellated structure of the bone is often filled with this substance.*

The quantity of bones collected from the seashore in Sandown, Brixton, Brook, and Compton Bays, during the last few years, is very considerable; the examples which I have seen at various times, and in the possession of different persons, must have belonged to between 150 and 200 individuals. And though from their abraded and mutilated condition, but few of the specimens were instructive, yet so large a number proves that the country from which the Wealden deposits were derived, must have teemed with colossal oviparous quadrupeds. Some of the rolled bones indicate more gigantic animals than even the largest from Tilgate Forest, and now in the British Museum.

The Rev. Gerard Smith, in 1825, obtained several fragments of bones of reptiles from Sandown Bay; and in 1829 a considerable number was found by Mr. James Vine, near Bullface Ledge; the latter are now in the collection of the Geological Society of London. In 1834 Mr. John Smith, of Yaverland Farm, collected several large vertebræ of the Iguanodon, portions of two thigh bones, and many fragments of smaller bones: these relics were presented to the Oxford Museum.†

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* Some of these osseous boulders and pebbles afford interesting sections for the microscope. Slices from specimens presented to me by the Rev. Charles Pritchard, of Clapham Common, beautifully display the cancellated structure of the bone, with the cells lined with pyrites and calcareous spar.

† See a memoir, by the Rev. Dr. Buckland, on "Bones of the

It must be borne in mind that these fossils have, for the most part, been picked up by persons wholly uninstructed as to the characters which alone render such specimens interesting. What the waves cast up on the strand, the fishermen gather together, the casual visitor selects such as please his fancy, and the remainder are thrown away, or employed to pave the footpath, or surround the flower-border of the cottager's dwelling.*

The remains hitherto found, are separate bones belonging to the well-known Wealden reptiles, viz. the *Iguanodon*, *Hylæosaurus*, *Megalosaurus*, and *Streptospondylus*; and the *Cetiosaurus*, *Plesiosaurus*,† and two or more kinds of turtles. I have seen but two teeth; a fragment of one belonging to the megalosaurus, and the specimen figured in lign. 27.

THE IGUANODON.—Of this most gigantic of terrestrial reptiles, which, when living, must have more nearly resembled in its magnitude and huge proportions, the largest of our living pachydermata, than any of the saurian order to which it belongs, many vertebræ, portions of ribs, and bones of the extremities, have been discovered in the Wealden at Sandown Bay, and at Brook and Brixton. The vertebræ are invariably deprived of their processes; even the neural arch is in general destroyed, and the

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Iguanodon from the Isle of Wight," "Geological Transactions," vol. iii. new series.

* The largest toe-bone of the iguanodon now in my possession was obtained from a row of stones placed round the flower plot of a cottage near Brixton. I much regret that my professional engagements have rendered it impossible for me to attempt to remedy the evil mentioned in the text.

† Having given a concise exposition of the osteological characters of these extraordinary beings in the "Medals of Creation," (vol. ii. p. 684, ch. xvii. and xviii.) with full instructions for the collection of their remains, to that work I beg to refer the reader desirous of pursuing these inquiries.

waterworn body, or centrum of the bone, alone remains.* The specimens are commonly permeated with pyrites, and, in consequence, are of great weight. The long bones of the limbs are for the most part mutilated, and but seldom have an articulating extremity so perfect as to indicate the individual bone. Some of the fragments, however, retain characters sufficiently recognisable, and have unquestionably belonged to reptiles of enormous size. I obtained from Sandown Bay the lower half of a *tibia* (large bone of the leg), having the extremity that articulates with the foot perfect; the circumference of this bone is four times that of a perfect tibia of a young iguanodon, which is one foot long: when entire; its length must therefore have been nearly four feet. The corresponding thigh-bone, estimated from the relative proportions of a femur and tibia in juxtaposition, would be a foot longer: the entire length of the leg and thigh to which the Sandown fossil belonged, must consequently have been upwards of nine feet.

The most perfect femur, or thigh-bone, collected in the Isle of Wight, was dug out piecemeal from a fallen mass of the cliff in Brook Bay: it evidently belonged to an aged individual, and though squeezed and somewhat distorted by pressure while softened by long immersion in the clay in which it was imbedded, well displays the peculiar characters of this part of the skeleton of the iguanodon. It is 3 feet 4 inches in length. The figure in lign. 26 is a representation of this specimen, as it would appear if uncompressed. The femur of the Iguanodon is so remarkable, that even fragments may readily be distinguished; and as portions of this bone are not unfrequently to be met with in the clay cliffs or on the shore, I subjoin the following description.

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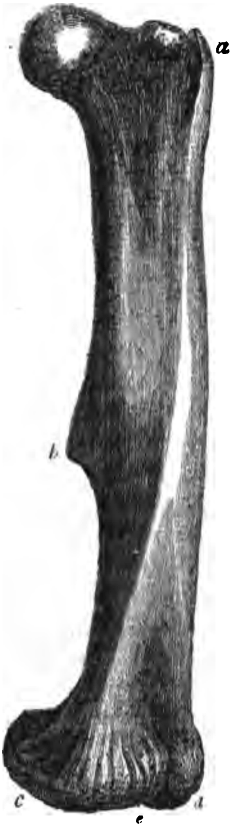
* As shown in lign. 138, fig. 8, p. 697, "Medals of Creation," vol. ii. The perfect form of a caudal vertebra of the Iguanodon is represented in fig. 3 of the same lignograph.



LIGN. 26.—LEFT FEMUR OF AN IGUANODON. From Brook Bay.
(*The original, 40 inches in length.*)
a, Upper trochanter.
b, Middle trochanter.
c, Inner, *d*, outer condyle.
e, Groove between the condyles.

The head is hemispherical, and projects inwards; a laterally flattened process, or trochanter (lign. 26, *a*), forms the external boundary of the neck of the bone, from which it is separated by a deep and very narrow vertical fissure. The shaft is sub-quadrangular; a slightly elevated ridge, produced by the union of two broad, flat, longitudinal surfaces, extends down the middle of the anterior face, and diverging towards the inner condyle, gradually disappears. The shaft terminates below in two large rounded, and laterally compressed condyles (*c*, *d*), which are separated in front and behind by a deep groove (*e*). Near the middle of the shaft, the mesial, or inner edge, forms a compressed ridge, which extends into an angular projection, or inner trochanter (*b*). Thus the upper part of the femur may be known by the presence of the upper trochanter (*a*); and if that process is broken away, the fractured surface indicating its position will be detected. If a fragment of the middle part of the shaft only is found, the flattened angular spaces, and the submedian trochanter (*b*), or the mark of its attachment, will identify it. The lower extremity of the femur may be distinguished by the deep groove (*e*) between the condyles, both in front and behind. The long bones of the iguanodon have a large medullary cavity.[*]

Several bones of the feet and toes have been found in this locality. Dr. Buckland obtained a toe-bone of enormous size from Sandown Bay; it is six inches long and fifteen inches in circumference, at the largest extremity.[†] The metatarsal and phalangeal bones of the iguanodon are short and thick, and so much resemble those of the hippopotamus, that Baron Cuvier at first supposed the specimens from Tilgate Forest belonged to that animal.

TOOTH OF THE IGUANODON.—With the thigh-bone above described were found several dorsal and caudal vertebræ, many fragments of ribs, and the only tooth of the iguanodon I have obtained from the Island. It evidently, like the femur, belonged to an adult, and very probably to the same individual. The crown is worn down almost to the neck of the tooth, and shows the remarkable character imparted to the teeth of this herbivorous reptile, by the trituration of its food,—a character in which they differ from the teeth of any other known reptile, either living or extinct; for all other herbivorous reptiles chip off and swallow their food whole, the construction of their jaws not admitting of a grinding motion.[‡] From this condition of the crown, as shown in the tooth figured below, it is obvious that the iguanodon fed on vegetables, and masticated its food like the horse and other herbivorous mammalia: while the base shows the imprint of the successional tooth, which, by its pressure, occasioned the absorption of the fang of the old one. In the perfect tooth, the crown is of a prismatic form, with three or four longitudinal ridges down the front, and a broad denticulated margin on each side.* The resemblance between the unworn teeth of the iguanodon and those of the iguana, a herbivorous lizard of the West Indies, suggested the name of this colossal extinct reptile; but the teeth of the iguana are very small, not exceeding in size those of the mouse.

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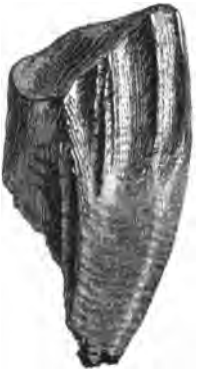
[*] "Medals of Creation," vol. ii. p. 748.

[†] "Geol. Trans." vol. iii. pl. 41.

[‡] For an account of the development of the teeth of the Iguanodon, see "Fossils of Tilgate Forest," p. 72; and "Wonders of Geology," p. 390.



LIGN. 27.—TOOTH OF AN IGUANODON.
From the Wealden, Brook Bay.

Sections of the teeth are beautiful objects under the microscope, and show that the structure of the dentine, or tooth-ivory, is coarser than in other reptiles, and resembles that which characterises the teeth of the Sloth tribe. The crown of the tooth is incrusted with an external coating of enamel, which is thick in front, and thin on the inner surface. In consequence of this disposition, and of the dentine being hardest in the anterior part, the grinding surface of the tooth is always worn away obliquely, and a sharp cutting front edge of enamel maintained in every stage.*

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* "Medals of Creation," p. 741.

SACRUM OF THE IGUANODON.—A very remarkable peculiarity in the anatomical structure of the iguanodon, and of the hylæosaurus and megalosaurus, consists in the *sacrum* being composed of five vertebræ anchylosed, or fixed together, into a solid column; whereas in all living saurians the sacrum consists of but two vertebræ. The neural arches of the vertebræ are shifted to the interspaces between the bodies of those bones, by which more solidity is given to the pelvic arch. Professor Owen (who first pointed out these modifications of structure) states that the sacrum of the ostrich presents the same characters, and in the young bird the individual vertebræ, and the remarkable change in the relative position of the vertebral elements, may be clearly traced.

Though these details are of the greatest interest to the comparative anatomist, I should not have dwelt upon them in the present work, were it not probable that specimens of this part of the skeleton will come under the notice of the visitor, and would, perhaps, from their unsightliness, be rejected. I have obtained from Brook Bay several water-worn portions of the sacrum, consisting of two or three anchylosed vertebræ; the finest example of the entire series belonging to a large individual, was found on this coast.†

FORM OF THE IGUANODON.—From the numerous detached bones that have been collected from various localities of the Wealden, and with the aid of the few specimens in which several are collocated in the same block of stone, the size

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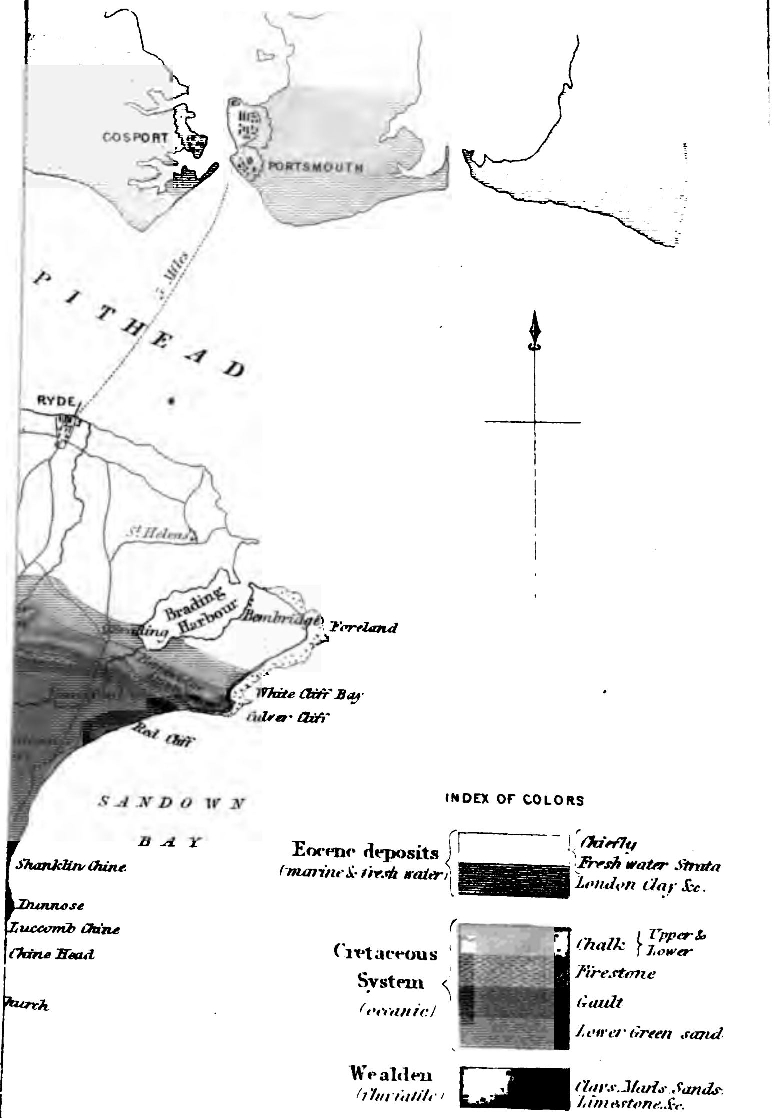
* "Wonders of Geology," vol. i. p. 390.

† This fossil is in the interesting museum of W. D. Saull, Esq., of 15, Aldersgate Street, City, to which visitors are, with great liberality, admitted every Thursday at twelve. Mr Saull's collection of organic remains contains many specimens from the Isle of Wight.

PL. XX.



J. W. Lowry fc.

and proportions of the body and limbs of the iguanodon may be determined; yet but a vague idea of the form and appearance of the original animal can be derived from the relics hitherto discovered. For the great discrepancy between the known parts of the skeleton, and the corresponding bones in the largest existing saurians, renders it vain to attempt the restoration of the form of this colossal reptile, till the skull, jaws, &c. are known. In all probability the entire or a considerable portion of the skeleton of a young iguanodon, will sooner or later be brought to light, and yield the information necessary to enable the palæontologist to reconstruct the skeleton, and delineate the form of the living original.

In the present state of our knowledge we may, however, safely conclude, that the body of the iguanodon was equal in magnitude to that of the elephant, and as massive in its proportions; for being a vegetable feeder, a large development of the abdominal region may be inferred. Its limbs must have been of a proportionate size to sustain so enormous a bulk; one of the thigh-bones (in the British Museum) if covered with muscles and integuments of suitable proportions, would form a limb seven feet in circumference. The hinder extremities, in all probability, presented the unwieldy contour of those of the hippopotamus or rhinoceros, and were supported by a very strong short foot, the toes of which were armed with claws like those of certain turtles.* The forelegs appear to have been less bulky, and furnished with hooked claws resembling the ungueal phalanges of the iguana. The teeth demonstrate the nature of the food required for the support of this herbivorous reptile, and the power of mastication it enjoyed. The palms, ferns, cycadeous plants, and coniferous trees, with which its remains are associated, indicate the flora adapted for its sustenance. But the physiognomy of this creature, from the form of the skull and jaws, constructed as the latter must have been to give support to the powerful muscles necessary for the trituration of tough vegetable substances, must have remarkably differed from that of all known saurians.

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* "Wonders of Geology," pl. III.

The length of the iguanodon has been variously estimated, the difference in the computation depending chiefly on the length assigned to the tail, which in the iguana and many other lizards is much longer than the body. If the tail of the fossil reptile was slender, and of the same relative proportions as in the iguana, the largest individual would be fifty or sixty feet long; but it is more probable, and in fact almost certain from the shortness of the bodies of the caudal vertebræ, that the tail was short, and flattened in a vertical direction, as in certain living reptiles—for example, the doryphorus; the length, therefore, would be reduced to little more than thirty feet.*

From what has been advanced we may conclude that the iguanodon was a gigantic but inoffensive herbivorous reptile, which lived on the ferns, cycadeæ, palms, and coniferæ that constituted the flora of the country of which it appears to have been the principal inhabitant.

HYLÆOSAURUS, OR WEALDEN LIZARD.—This is another reptile of the Wealden, possessing the same remarkable conformation of the sacrum as the iguanodon. It is distinguished by a peculiar modification of the bones composing the sternal arch, and by its osseous dermal appendages: like the bones of the former reptile, its remains were first observed in the strata of Tilgate Forest.

The scapula is like that of the crocodiles, while the coracoid bone is of the lacertian type. The ribs have the bilobed head, as in the crocodiles, associated with the arched and rounded process of the lizards, and an enormous expansion of the bone at its spinal curvature. This reptile possessed a very formidable dermal covering: it had rows of elliptical and circular dermal bones along each side of the vertebral column, and appears to have been armed with a series of angular spines of great size, arranged along the middle of the back; in the same manner as the dorsal fringe of the iguana. The structure of the bone composing these dermal processes closely resembles that of the ligamentous fibres of the *corium*, or skin, and seems to have resulted from an ossified condition of the dermal integument. A few detached vertebræ of the hylæosaurus, recognisable by their perfectly circular and nearly flat extremities, have been found in the Weald clay at Brixton.*

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* "Medals of Creation," p. 751.

MEGALOSAURUS.†—This name was given by Dr. Buckland to an enormous reptile, of which teeth and bones were first observed in the oolitic limestone of Stonesfield, near Oxford, and afterwards in the Wealden strata. The teeth present a striking contrast to those of the iguanodon; they are sabre-shaped, with trenchant serrated edges. The original was probably carnivorous, and nearly thirty feet in length. As it was contemporary with the iguanodon and several other large saurians, it may have preyed on their young and on the lesser reptiles. Many teeth, vertebræ, and portions of the femur of this animal, have been found in the island. The vertebræ are not subquadrangular like those of the iguanodon, but are cylindrical at the ends and contracted in the middle, and have a very smooth surface. The femur is nearly cylindrical and slightly bowed; it has two large rounded prominences, or trochanters of nearly equal size, below the head of the bone; it may therefore easily be distinguished from the thigh-bone of the iguanodon.

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* See "Medals of Creation," p. 734, and "Memoirs on the Fossil Reptiles discovered in Tilgate Forest." "Philos. Trans." part II. for the year 1841.

† See Dr. Buckland's "Bridgewater Essay."

Cetiosaurus.—This extinct reptile, as its name imports, bore some resemblance to the cetaceans. The vertebræ are almost circular at the ends, and have a very short body; the front articulating surface is nearly flat, and the other concave, in the dorsal vertebræ, but in the caudal both ends are deeply hollowed; they are very large, often eight inches in diameter. By these characters the vertebræ of the cetiosaurus may easily be recognised. I have obtained several from the Weald clay at Sandown and Brook. The original animals are supposed to have been of aquatic, and probably of marine, habits, on the evidence of the sub-biconcave structure of the vertebræ, and of the coarse cancellous tissue of the long bones, which are destitute of a medullary cavity. They must have rivalled the whales in bulk, for some remains indicate a length of forty or fifty feet.*

Streptospondylus.—Among the large vertebræ washed up on the shore in Brixton Bay, I found several with one end convex and the other concave; these belong to the extinct crocodilian reptile called *Streptospondylus* (meaning *reversed-spine*), because these vertebræ are arranged in the spinal column in a position the reverse of that which obtains in all other reptiles of the same osteological type; for the convexity or ball of the vertebræ is placed anteriorly, whereas in the crocodile, &c. it is in the opposite direction.† The original, in its form and habits, probably bore a general relation to the crocodiles.

Plesiosaurus.—The splendid collection in the British Museum, which contains several perfect skeletons of different species of this genus of extinct marine reptiles, must be too well known to render any description necessary of the osteological characters of the plesiosauri and ichthyosauri. A few vertebræ of plesiosauri are the only remains of these animals I have obtained from the Island.

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* "Medals of Creation," vol. ii. p. 726.

† "Cuvier's Recherches sur les Ossemens Fossiles," tom. V. pl. 6.

FOSSIL TURTLES.—Of chelonian reptiles, waterworn fragments of bones are the only vestiges that have come under my notice. Some of these fragments in all probability belong to the *Trionyx Bakewelli*, a species which occurs in the Wealden strata of Tilgate Forest,* and is characterised by the granulated surface of the costal plates, and a dermal covering of tortoise-shell, as is shown by the imprints of the scales left on the bones. Except in possessing a defensive integument of this kind, this extinct chelonian must have resembled the existing predaceous soft turtles; and doubtless like them inhabited the mud-banks of rivers, and preyed upon the eggs and young of the larger reptiles, and on the uniones and other mollusca, the shells of which are often found associated with its remains.

IMPRINTS ON SANDSTONE.—We must here conclude our description of the fossils that have been discovered in the Wealden strata of the Isle of Wight; to attempt a full exposition of the characters and relations of these organic remains, would require a volume expressly devoted to the subject. A few additional remarks are, however, necessary on some anomalous appearances in the sandstone of Brixton Bay, that have recently come under my notice. The occurrence of imprints resembling the foot-tracks of birds and reptiles, on the surface of slabs of sandstone of very ancient formations, must be known to the well-informed reader, from the lucid illustration of the subject in Dr. Buckland's "Bridgewater Essay." Among those supposed foot-prints are several of large dimensions, described under the name of *Chirotherium*, which are conjectured to have been made by some enormous three-toed reptile, passing over the stone when it was in a soft state. Others equally colossal, from the arrangement of the markings on the slabs indicating the progressive footsteps of bipeds, have been ascribed to gigantic extinct birds.* The layer of clay, or sandstone, overlying these imprints, generally retains casts of them, which appear in relief on the surface of the slabs when removed; in other instances the cast of a single mould alone remains, and being more consolidated than the matrix, is often extracted whole. Several large sandstone casts of this kind were discovered last year in the Wealden sands at Hastings, and sent up to the Geological Society. A similar cast has been obtained from the Wealden sand in the cliff in Brixton Bay, and is in my possession. This specimen is a solid tripartite mass of fawn-coloured sandstone; the middle process is fifteen inches, and the two lateral projections are twelve inches in length; the greatest thickness is six inches; the processes are laterally compressed and rounded at the extremities, and united to one common base. As the origin of these singular concretions is very problematical, every specimen should be preserved; and if several occur on the same bed of sand, their relative position should be carefully ascertained.†

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* "Geology of the S.E. of England," p. 255. "Medals of Creation," p. 778.

ANCIENT RIPPLE-MARKS.—Connected with this subject are the ripple-marks so often pervading extensive surfaces of sands, sandstones, and clays, in sedimentary deposits that have been formed on sea-shores, or along the banks of rivers, or in bays, deltas, lakes, and estuaries, in comparatively shallow water. In many parts of the Wealden formation these appearances are very striking; especially in the vicinity of Horsham,* and in the quarries in Tilgate Forest in Sussex.† The slabs of limestone, clay, and sandstone, exposed in recent falls of the cliffs along the southern shores of the Island, are frequently covered with ripple-marks.

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* "Medals of Creation," p. 708.

† The method adopted to obtain impressions from engraved monumental brasses, namely, the placing of tough thin paper over the surface of the inscription or effigies, and rubbing it freely with the black composition termed "heel-ball," which adheres to the parts in relief, but leaves the cavities white, will be found convenient for obtaining an accurate plan and outline of the imprints on the sandstone. This process is also applicable to any fossil that has a surface flat and firm enough to bear the friction when covered by the paper. I have often taken in a few minutes imprints of the plates of turtles, scales of fishes, &c., sufficiently distinct to exhibit the general characters of the surface of the specimens.

Every one must have noticed when walking by the side of a river at low water, or on the sands of the seashore, that if the water has been agitated by the wind, the surface of the mud or sand is furrowed more or less deeply by the rippling of the waves; the markings presenting various appearances according to the force and direction of the wind and currents. The undulations on the surface of the sandstone have arisen from similar operations. In many instances the stone is so rough as to be employed in stable-yards, where an uneven surface is required to prevent horses from slipping as they pass over. Sometimes the furrows are deep, denoting that the water was much agitated, and the ripple strong; in other instances the undulations are shallow, and intersected by cross-ripples, indicating a change in the direction of the waves. Some slabs are covered by slightly elevated, broad ridges of sand, made up of gentle risings disposed in a crescent shape; these have been produced by rills flowing into the river, during the recession of the tide. The rippled surfaces often bear traces of the trails of mollusca, and annelides, and in some strata, imprints of the claws of crustaceans, of the pectoral fins of certain fishes, and of feet of reptiles have been observed.* But I have never detected unequivocal evidence of footmarks of any kind in the Wealden strata. Impressions of vegetables, several of which appear to have been produced by grasses, were abundant on some recently exposed slabs near Brook Point, on my late visit; the vegetable matter had evidently been changed to carbon, which was in a great measure washed away, but enough remained to point out the origin of the markings. I have observed similar appearances on slabs of sandstones and clays lying on the embankments of the recently constructed Tonbridge Wells Railway.

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* These were first noticed by Mr. Lyell in 1822, and described in a letter addressed to the author.

† It is singular, that although Professor Playfair mentions the cause of this appearance as undoubted, yet so little attention or credit was given to the statement, that my description of the phenomenon was received with much hesitation.

Summary.—And now, ere we depart from these shores, and bid farewell to scenes so fraught with interest and instruction, I would detain the reader a brief space, and while the data are before us, endeavour to interpret the nature of those physical revolutions of which they afford such unequivocal evidence. It appears, indeed, scarcely possible for the most incurious observer while sitting on these rocks of petrified trees, and surrounded by fossil bones of enormous reptiles, and heaps of river-shells obtained from the neighbouring cliffs, not to speculate on the causes which have given rise to these extraordinary results. For as a profound thinker has justly remarked, "when any natural phenomena are for the first time observed, a tendency immediately develops itself in the mind to refer them to something previously known, and bring them within the range of acknowledged sequences."†

It was with a view of inducing a train of thought which should lead the intelligent stranger, unfamiliar with the nature of geological evidence, to attempt the interpretation of the appearances presented to his notice, that this excursion was introduced by some general remarks on the changes effected on the surface of the land, by the agency of streams and rivers.

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* See Dr. Buckland's "Bridgewater Essay."

† "On the Correlation of Physical Forces," by W. R. Grove, Esq., M.A., F.R.S. &c. London, 1846.

Let us test the facts before us by the principles enunciated in those remarks. We have here strata of great thickness, made up of laminated detritus, identical in appearance and composition with the consolidated mud-banks of rivers and deltas; we have rafts of drifted pine-trees, and the remains of cycadeous plants, and arborescent ferns —innumerable layers of freshwater shells and crustaceans, with large mussels resembling the unionidæ of the rivers of America—heaps of waterworn bones of colossal oviparous quadrupeds, which comparative anatomy instructs us belong to types of organisation long since extinct—in fine, an accumulation of transported materials teeming with the spoils of some unknown region, associated with fluviatile mollusks and crustaceans, without any intermixture of marine exuviæ. What is the obvious inference—what the unavoidable conclusion at which we must arrive? Unquestionably, that these deposits were the delta of a river, which flowed through a country possessing a fauna and flora of a tropical character, and essentially distinct from any now known to exist.

THE COUNTRY OF THE IGUANODON.—We have here then data from which, by the method of induction previously explained, we may restore, as it were, the region whence the Wealden strata were derived, the animals by which it was inhabited, and the vegetables that clothed its surface. Whether that country was an island or a continent cannot, perhaps, be determined; but that it was diversified by hills and valleys, and irrigated by streams and rivers, and enjoyed a climate of a higher temperature than any part of modern Europe, is most evident. Arborescent ferns, palms, coniferous trees, and cycadeous plants constituted its groves and forests, and delicate ferns the vegetable clothing of its soil; and in its fens and marshes the equiseta, and plants of a like nature, prevailed. Its principal herbivorous quadruped was the enormous lizard, the iguanodon; its carnivora, the megalosaurus and other predaceous reptiles; crocodiles and turtles frequented its rivers, and deposited their eggs on the banks and shoals; and its waters teemed with fishes, mollusca and crustaceans. That the soil was of a sandy nature on the hills and plains, and argillaceous in the lowlands and marshes, may be inferred from the vegetable remains, and the lithological character of the strata in which they are imbedded. Some inferences relating to the prevailing atmospheric condition of the country may also be drawn, from the undulated surfaces of the sandstones, and from the fossil trees. In the former we have proof, that when the land of reptiles existed, the water was rippled by the breezes, which then, as now, varied in intensity and direction in a brief space of time; by the latter, that in certain situations the wind blew from a particular quarter for a great part of the year, and that the mean annual temperature was as variable as in modern times. From what has been advanced, it must not, however, be supposed, that the country of the iguanodon occupied the site of the south-east of England; and that the animals and terrestrial plants of the Wealden lived and died near the spot where their relics are entombed. For with the exception of the shells and crustaceans, which probably inhabited the delta, all the fossil remains bear marks of having been transported from a great distance. But though three-fourths of the bones we discover have been broken and rolled—the teeth detached from their sockets,—the vertebræ and bones of the extremities, with but very few exceptions, disjointed, and scattered here and there—the stems and branches of the trees torn to pieces, and deprived of their foliage,—there is no intermixture of sea-shells, nor of beach or shingle; these remains have been subjected to abrasion from river currents, but not to attrition from the waves of the ocean. The gigantic limbs of the large reptiles could not have been dissevered from their sockets without great violence, except by the decomposition of their tendons from long maceration in water; and if the latter had been the sole cause, we should not find the bones broken and separated, but lying more or less in juxtaposition, like the skeletons of the plesiosauri in the lias. The condition in which these fossils occur proves that they were floated down the river with the rafts of trees, and other spoils of the land, till, arrested in their progress, they sank down, and became imbedded. The phenomena here contemplated cannot, I conceive, be satisfactorily explained upon any other grounds; and the source of the mighty stream which flowed through the country of the iguanodon, must therefore, like that of the Mississippi, have been hundreds, perhaps thousands, of miles distant, from the delta accumulated in the course of ages at its mouth.

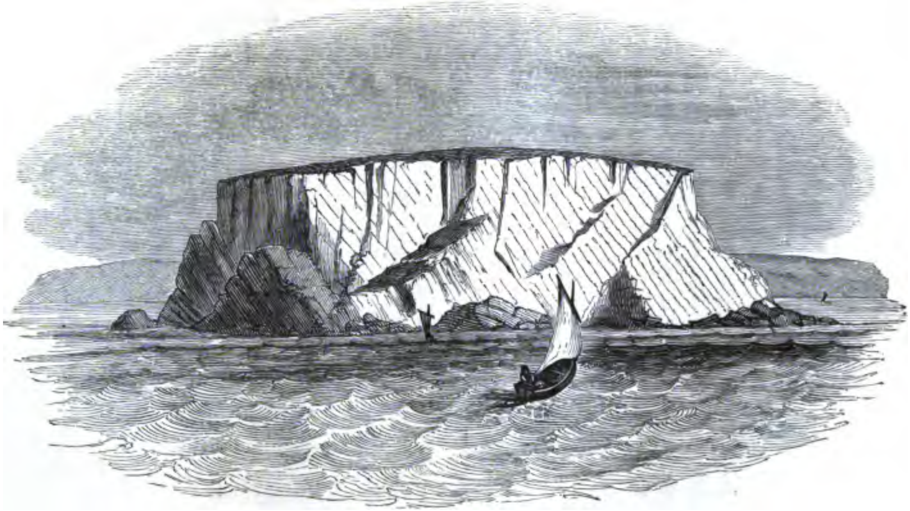
VOYAGE ROUND THE ISLE OF WIGHT.—As during the summer months, excursions round the Island are almost daily made by the steamers, an opportunity is afforded of obtaining a general view of the geology of the coast in the course of a few hours. To a person acquainted with the physical structure of the country, such a voyage is alike agreeable and instructive, and the reader will find a day well spent in taking a rapid survey of the most important geological sections which the coast scenery exhibits. The steamers leave Cowes or Ryde, and take an easterly or westerly course, according to the state of the tide. In the following brief notice, the localities most worthy of remark, in a geological point of view, are described in the order they will appear, if the former route be pursued.

Proceeding from Ryde to the eastward, we coast along the northern shore of the Island, which is almost everywhere covered with vegetation to the water's edge: a low bank, or cliff, of the freshwater eocene marls and limestones, being the only indication of its geological structure. St. Clare, the charming seat of Col. Vernon Harcourt, stands on an eminence of these deposits. Doubling the eastern point of St. Helen's, Bembridge Foreland appears, surmounted by the range of chalk hills that terminates at Culver Cliff. We cross the mouth of Brading Haven; the little town of Brading is seen nestling in a grove of elms at the foot of the chalk downs, which form the western boundary of the view. The upper horizontal freshwater strata on the northern extremity of Whitecliff Bay (see p. 90) next appear, and a good view is soon obtained of the bay, bounded on the south by the magnificent chalk cliffs of the Culvers.

On reaching the extremity of Whitecliff Bay, the vertical section of the highly inclined chalk strata, which forms the eastern promontory of the Island, is finely displayed. (See Pl. XV.) The dip of the strata, varying from 50° to 70° towards the north, is clearly marked by the layers of flint nodules, which are distinguishable a quarter of a mile from the shore. Culver Cliffs, which the reader will remember, are the eastern termination of Bembridge Downs (see lign. 8, p. 90), are between 300 and 400 feet high, and about a quarter of a mile in breadth. When off the promontory, a very interesting geological view is obtained; at one glance we see the nearly vertical chalk, bounded on the right (north) by the eocene strata of Whitecliff, and on the left (south) by the greensand of Redcliff.

Upon doubling the headland, we enter Sandown Bay, (see the section, lign. 9, p. 96); the lower chalk, firestone, galt, and greensand appearing in succession, like sloping bands of yellowish white, green, blue, and deep red; the latter denoting the ferruginous sands of the lower group.

Pl. XV.



CULVER CHALK CLIFFS; FROM THE SEA.

Sandown Fort is now visible, and marks the low tract consisting of the Weald clay (p. 95). The new church and little town of Sandown are seen on the brow of the sand cliffs which form the western side of the bay, and extend toward Shanklin, retaining the same dark red ferruginous colour as those at Redcliff. The eastern termination of the southern range of chalk, forming the lofty downs above Shanklin, next appears, and seaward, the high but subordinate cliff of greensand at Dunnose Point. The dip of the strata in the cliffs on each side of Sandown Bay, and the anticlinal axis formed by the elevation of the Wealden, may be distinguished by means of a good telescope.

Off Dunnose, we lose sight of the inner range of chalk downs, and gain the region of the Undercliff, which from the sea presents, in the foreground, a line of fallen masses of rock and strata scattered along the sea-shore; and above, a verdant terrace covered with trees and shrubs, with here and there houses peering out from amid the foliage—the barrier of firestone capped with chalk, surmounting the terrace on the north, and bounding the view for a distance of six miles (see p. 184). The ledges of cherty firestone projecting like lines of masonry along the face of this inland cliff, may be distinguished, if the steamer keeps within the usual distance of the shore.

Nearing Blackgang, St. Catherine's appears towering above the western termination of the Undercliff. The Sandrock hotel is seen standing on a ledge high up the precipitous escarpment of the greensand, which here forms the sea-cliff (see p. 173), near the foot of the inland cliff of firestone; the latter rises to within 200 feet of the summit, which is nearly 800 feet above the level of the sea. The ruins of the tower of St. Catherine surmount the whole. The white chalk is seen forming the top of the downs, and appearing from the sea as an inconsiderable layer, immediately over Blackgang.

From Blackgang to Atherfield the cliffs are entirely composed of the greensand, and the general direction of the beds from east to west may be easily traced. (See lign. 17, p. 157.) The clays and sands along this part of the coast present a very curious appearance. The lower strata are generally dark, indeed, almost black, but the uppermost are of a light ferruginous colour; and wherever springs are thrown out by the clay partings, the cliffs are stained with broad streams of ochreous yellow. This appearance is correctly attributed by Sir Henry Englefield, to the action of the water that percolates from the surface of the soil through these strata, and issues out on the face of the cliff; the oxidation of the sands and clays is the result of the decomposition of the sulphuret into peroxide of iron. This change is often accompanied by the formation of crystals of sulphate of lime or selenite.* The abundance of nodules of pyrites in these clay cliffs, as well as in those of the Wealden, is so great, that considerable quantities of this mineral are collected on the shore by the cottagers, for sale to the copperas manufacturers.

Approaching Atherfield, the undulated outline of the distant horizon on the north, denotes the re-appearance of the central range of chalk downs, which we lost sight of behind Dunnose Point, and is here seen extending in a south-westerly direction towards the southern shore. The station-house on Atherfield Point marks the locality where the junction takes place between the Wealden and the greensand (p. 162).

The next interesting geological features of this coast, are the cliffs at Brook Point, but the steamers pass at so great a distance from the shore, that the general bearing of the strata only can be distinguished. In the long sweep exposed in these bays (p. 153), the greatly elongated arch, formed by the anticlinal axis of the Wealden (p. 156), may be distinctly made out in a clear state of the atmosphere. Shalcomb Down (p. 160) now forms the inland distance on the north; and as we near Compton Bay, the middle chalk range is seen extending to the shore, and the sea washes the base of the magnificent line of chalk hills from Afton Down to the Needles.

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* A similar result has taken place in some of the railway clay embankments, and been productive of considerable injury to the works.

The position of the greensand, galt, and firestone, beneath the white chalk, in the cliffs west of Compton Chine, may be distinguished from a distance, owing to the contrast of colour presented by the upper and lower groups; as in Redcliff in Sandown Bay. Freshwater Bay (p. 142) is now gained, and the cliffs of the Mainbench, and of Scratchell's Bay, and the Needles, stand forth in all their sublimity. (See p. 144.) There is one point in Scratchell's Bay in which a magical effect is produced, by the sudden appearance of the richly coloured cliffs in Alum Bay, between the pure white pinnacles of chalk.

As we sail round the Needles, the distant Isle of Portland is seen on the western horizon, and on the north are the shores of Hampshire (p. 119). The vertical strata of Alum Bay (p. 107), and the freshwater series at Headon Hill (p. 111), are now on our right; and we perceive that the structure of this north-western extremity of the island is the counterpart of the north-eastern promontory at Culver Cliff and Whitecliff Bay, which we sailed by in the earlier part of our voyage. Colwell and Thorness Bays are next passed, and we land at Yarmouth to prepare for our excursion to the Dorsetshire coast.

CHAPTER XII.

GEOLOGICAL EXCURSIONS ALONG PART OF THE SOUTHERN COAST OF DORSETSHIRE.

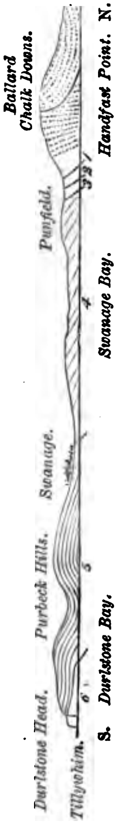
VOYAGE FROM YARMOUTH TO SWANAGE—SWANAGE BAY—THE PURBECK STRATA—FOSSILS OF THE PURBECK STRATA—THE PORTLAND OOLITE—GEOGRAPHICAL DISTRIBUTION OF THE STRATA—THE SOUTH-EASTERN COAST OF PURBECK—THE SOUTH-WESTERN COAST—WORBARROW BAY—LULWORTH COVE—FOSSIL TREES—DURDLE COVE—CHALDON DOWNS—RINGSTEAD BAY—THE ISLE OF PORTLAND—PETRIFIED PINE-FOREST—FOSSILS OF PORTLAND AND WEYMOUTH—RETROSPECT—COROLLARY.

Voyage from Yarmouth to Swanage.—At the distance of about fifteen miles across the channel, from the western extremity of the Isle of Wight, the south-eastern part of the county of Dorsetshire forms a peninsula, which is called the Isle of Purbeck. This district is of an irregular oval form, its greatest length from east to west is between thirteen and fourteen miles, and its average breadth from north to south, seven miles. It is composed of cretaceous, Wealden, and oolitic deposits, and a brief notice of its geology will form an interesting and highly instructive sequel, to our survey of the corresponding strata in the "beautiful island."

At Yarmouth a cutter may be engaged to convey the visitor to Swanage, a little town on the eastern coast, situated near the once celebrated quarries of Purbeck marble. But during a great part of the year, steam-packets ply twice or thrice weekly from Portsmouth and Southampton, to Poole and Swanage, calling for passengers at Ryde, Cowes, and Yarmouth; so that the Isle of

Purbeck may be included in our geological excursions with but little inconvenience. This short voyage is very delightful in fine weather, for with a telescope the principal lines of strata may be traced along the distant coasts, and a comprehensive view obtained of the relations, and original continuity, of the now dissevered masses which form the dry land.

In sailing from Yarmouth towards the Isle of Purbeck, our course, after passing by the Needles, is to the west, and the chalk cliffs of Dorsetshire soon become distinctly visible; and we at once perceive, that if the vertical chalk range we are leaving behind were prolonged in a direct line to the west, it would unite with that towards which we are steering our little bark. Mr. Webster has graphically described the most striking features of the varied landscapes which successively appear in this voyage: "The Island we had just left assumed a very interesting appearance. The gradual rise of the northern side above the sea—the coloured strata of Alum Bay—those singular masses of rock the Needles—with the majestic chalk cliffs behind them of the most dazzling whiteness—and the precipitous face of the southern side of the downs above Freshwater—composed altogether a picture of the most romantic character. On the north lay the coast of Hampshire (see p. 119), consisting of tertiary clay cliffs, above which were seen the town of Christchurch, and several lesser places. As we approached the Dorsetshire side, I perceived that the chalk cliffs were of great height, forming the eastern end of the promontory called Handfast Point; on the north side of which lay Studland Bay, and on the south Swanage Bay. In these cliffs, which present a vertical section of the Isle of Purbeck from north to south, were seen, while we were yet some miles distant, several very large caverns; and towards the north end four or five detached masses of rock rising out of the sea; these were evidently isolated portions of the chalk, which like the Needles had resisted longer than the rest of the cliff, the destroying effects of the waves. When sufficiently near, I made the vessel lay to, that I might examine the stratification by a telescope; and I was surprised and delighted to find the south end composed of strata of chalk and flint quite vertical."*



LIGN. 28.—SECTION FROM BALLARD DOWN TO DURLSTONE HEAD, ACROSS SWANAGE BAY.
(*The distance about three miles.*)

1. Firestone. 2. Galt. 3. Greensand. 4. Wealden. 5. Purbeck Strata. 6. Portland Oolite.

SWANAGE BAY.—We land at the little town of Swanwich, or Swanage, where excellent accommodation may be obtained, and vehicles and boats hired for excursions by land or water. The exportation of stone is still so considerable as to give the place an aspect of cheerful activity.

The cliffs that extend across Swanage Bay, expose a transverse vertical section of the strata from north to south, and afford a key to the geological structure of the Island; as shown in lign 28.

In this line of coast, the entire series of deposits from the Chalk at Ballard Downs, to the Portland oolite at Durlstone Head, is displayed in the natural order of succession. This section will remind the reader of that from Shalcomb to Brook Point (lign. 18, p. 160); but in the latter, only the upper Wealden beds appear on the south, the lower group not being exposed to view.

The general dip of the strata is to the north, but the angle of inclination is not uniform, and some of the cretaceous and Wealden deposits present flexures and contortions of a very remarkable character. Before we stroll along the shore to collect specimens, and examine the strata in detail, it is desirable to engage a boat, and sail across the bay, that we may obtain a general idea of the geological structure of the country. From Swanage the cape or headland of Handfast Point, a chalk cliff 350 feet high, appears on the north; and to this spot we will direct our course. Doubling this promontory we enter Studland Bay,* and perceive that the coast is formed of the upper chalk, which emerges from beneath the eocene strata on the north at a very low angle, and continues round the extreme point of the cape, where several pinnacles, that may be regarded as representative of the Needles, guard the coast. A little to the south of this point, the layers of chalk and flint, which are as strongly defined as in Culver Cliff (p. 244), suddenly turn upwards in a curve, forming nearly a quarter of a circle, and abut against vertical strata of the same kind; "the vertical layers of flints meeting the bent part of the chalk, as so many ordinates would meet a curve, and decreasing in height as they get more under it."† (See lign. 28, Handfast Point.) This appearance, as Mr. Conybeare has clearly shown, is attributable to a fault or dislocation, which in part of its course coincides with the lines of stratification, The chalk in the curved and vertical strata is extremely indurated, but in the horizontal, is of its usual consistence. The vertical flints, like those in the Isle of Wight, are, for the most part, shattered (*ante*, p. 147), and the fragments separated from each other by the chalk. These flints do not fall to pieces in the hand, like those of Freshwater, Culver, &c., because the severed portions are firmly held together by the chalk in which they are imbedded; but there is the same variety in the size and form of the fragments, from large angular pieces to fine powder.*

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* Sir H. Englefield's "Isle of Wight," p. 164.

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* If the section, lign. 28, were prolonged, Studland Bay would appear on the north of Ballard Downs.

† "Geology of England and Wales," p. 110.

Southward of Handfast Point, near the foot of Ballard Down, there is a small cove or recess termed Punfield, in which strata of Firestone, Galt, Greensand and Wealden clay, are seen in a highly inclined position. The middle series of the Wealden deposits, the Hastings Sands, which are not visible in the Isle of Wight, form the line of cliffs from Punfield to Swanage. These beds consist of sands, clays, and calcareous grits, enclosing seams and disseminated masses of lignite, and containing bones of reptiles, &c. The sea-shore, as in Brook and Sandown Bays, is often strewn with fossil trees, and rolled bones of the Iguanodon and other animals, that have been washed out of fallen masses of the strata. The tract on which the town of Swanage stands, is on the line of junction between the Hastings beds, and the Purbeck group; the latter comprises clays, sands, and limestones, with bands of shelly marbles, calcareous shales, and coarse limestones, full of small paludinæ, cyclades, and other freshwater shells.

The spaces respectively occupied by these deposits, as measured along the foot of the cliff, are given by Dr. Fitton as follow:—

Firestone	250 paces.
Galt	200 —
Greensand	240 —
Weald clay	46 —

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* These appearances were first pointed out by Mr. Webster, whose descriptions will be found as faithful as they are lucid, by those who visit the scenes he has so exquisitely portrayed in the beautiful illustrations of Sir Henry Englefield's work. These phenomena may be most easily examined on the south side of the cliff at Handfast Point, where the shore is generally strewn with large masses of fallen chalk.

Hastings sands	3,500 paces.
Interval between the sand cliffs and the rise of the Purbeck strata . . .	200 —*

The cliffs in Durlstone Bay are entirely composed of the Purbeck strata; those in the middle are much bent and undulated, but in the southern part, the arrangement of the beds is well displayed. The termination of this coast at Durlstone Head, consists of the marine strata called the Portland oolite, which are seen to emerge from beneath the Purbeck hills. (See lign. 28.)

In the coast section thus briefly described we have, therefore, the following series:—

I. *The Cretaceous System*, comprising the upper and lower white chalk, firestone, galt, and greensand.

II. *The Wealden*, including the Weald clays, the Hastings beds, and the Purbeck.

III. *The Oolite*, of which the upper, or Portland group is alone visible.

Of these, the Purbeck and Portland strata are for the first time brought under the observation of the reader, and will therefore require more particular notice.

THE PURBECK STRATA.—The uppermost Purbeck bed is a green, calcareous, and for the most part friable, deposit, containing shells of a small species of Unio; beneath this is a stratum of the well-known marble, composed of an aggregation of the small river snail-shells already described (*Paludina elongata*, Pl. VI. fig. 2); a polished slice of this marble is figured in lign. 29. Some of the layers contain interspersions of the large paludinæ (*P. fluviorum*, Pl. VI. fig. 3) of the Sussex marble, and also a few small river mussels. I have seen polished slabs of this kind in which sections of bivalves (*Uniones*) formed the principal markings; these shells were associated with cyprides and very small fragments of bones, and vegetable detritus. The white and cream-coloured slates and coarser limestones, or Purbeck stone, as they are termed, are also shelly conglomerates, the prevailing shells being small species of the genera Cyclas, Cyrena, &c.*

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* "Geological Transactions," vol. iv. p. 207.

LIGN. 29.—POLISHED SLAB OF PURBECK MARBLE.
(Composed of petrified river snail-shells.)

The stone now quarried is in the upper part of the series of shales, clays, and limestones. Mr. Webster states, that in the thickness of 125 feet, there are more than fifty layers of useful stone; these include a remarkable deposit, twelve feet thick, termed "Cinder" by the workmen, and which consists of a regular oyster-bed. The lower 150 feet are made up of shales, clays, and shelly limestones, too friable to be of any value in an economical point of view. The total thickness, from the uppermost bed to the Portland marine limestone, is about 275 feet.† Fibrous carbonate of lime, in layers two inches thick, is often found adhering to the bands of marble, as in the instance observed in Sandown Bay (p. 97).

Fossils of the Purbeck Strata.—From what has been stated, the reader will be aware that the fossils of the Purbeck strata are identical in their general character with those of the upper divisions of the Wealden, described in

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[*] Some of the most ancient pavement in Ely Cathedral consists of slabs of the Purbeck bivalve limestone.

[†] Mr. Webster, in "Geological Transactions," vol. ii., new series. Mr. Webster mentions having found some nodular concretions of chert, containing silicified freshwater shells in the state of chalcedony. I have not obtained any specimens of this kind.

the previous chapters. They consist of river shells, drifted land plants, bones of saurian and chelonian reptiles, with the remains of fishes, and crustaceans; the absence of ammonites, echinites, zoophytes, &c., being as complete as in the Sussex Wealden.

Many bones of reptiles have been procured from Swanage cliffs,* and from the quarries in the neighbourhood; but the most remarkable fossil of this kind hitherto discovered, I had the good fortune to obtain, through the intelligence and liberality of Robert Trotter, Esq., F.G.S., of Sussex.

THE SWANAGE FOSSIL CROCODILE.—In the summer of 1837, the workmen employed in one of the quarries near Swanage, had occasion to split asunder a large slab of the fawn-coloured limestone, when, to their great astonishment, they perceived many bones and teeth imbedded on each of the exposed surfaces. As this was no ordinary occurrence, —for though scales of fishes, shells, and fragments, of bones, were frequently met with, an assemblage of bones had never been observed before,—both slabs were preserved; and Mr. Trotter, who casually visited the place, purchased them, and presented them to me. These slabs measure 3 feet 10 inches by 3 feet, and are a few inches in thickness. Many of the bones were split asunder in separating the stone, others were deeply imbedded, and of a few, imprints alone remain. Much labour and care were required to unite the several parts of the bones, to develop the others, and bring the specimens into the state in which they now appear. On one slab, a considerable portion of the left side of the lower jaw, with two teeth, is preserved; and several teeth, and numerous dermal or skin-bones, of a very peculiar form, are dispersed about the stone.† The bones of the pelvis, and some of those belonging to the extremities, with many caudal and dorsal vertebræ, and chevron bones, are imbedded in the same slab. The corresponding piece of stone bears the impression of the portion of jaw, and contains numerous dermal bones, vertebræ, &c.* Teeth and dermal bones of this reptile were among my earliest discoveries in Tilgate Forest; several teeth are figured by Baron Cuvier, in *Oss. Foss.* tom. v., and in my "Fossils of Tilgate Forest." In the latter work portions of dermal bones, or scutes, are represented, and described as belonging to the freshwater turtles called Trionyces; and it was not until I discovered more perfect specimens that the true nature of these bones was apparent. The gigantic Gavial of the Ganges, has rows of osseous scutes, which are deeply pitted on the external surface. Those of the Swanage Crocodile are distinguished by a lateral conical projection, which fits into a corresponding depression on the under surface of the opposite angle of the adjoining plate. Numerous hexagonal and pentagonal scutes, articulated together by marginal sutures, also entered into the composition of the cuirass of this reptile, which therefore, must have constituted a flexible and impenetrable coat of armour, capable of resisting the attack of the most formidable assailant. The teeth of the Gonio-

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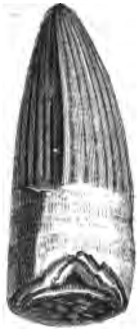
* A description of some bones of the Iguanodon found on the shore, half a mile north of Swanage, is given by Dr. Buckland in "Geological Transactions," vol. iii. p. 429, new series.

† These dermal bones are figured in "Medals of Creation," vol. ii. p. 702.



LIGN. 80.—TOOTH OF THE SWANAGE CROCODILE.
(*Goniopholis crassidens.*)

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* The slab first described is figured in the "Wonders of Geology," vol. i. pl. i. Both specimens are now placed in an upright glass case against the wall, near the doorway of the room containing the remains of the Iguanodon and other Saurians, in the Gallery of Organic Remains, in the British Museum.

pholis (lign. 30) resemble in form those of the crocodile, but he crown is strongly marked with numerous sharp, well-defined, longitudinal striæ, and there is a prominent ridge down the middle of each side. The successional teeth are often found in the base of the perfect old teeth, as in the crocodile. Some specimens from Tilgate Forest are two inches long, and half an inch in diameter at the base.* The vertebræ are biconcave, and have an irregular medullary cavity in the centre of the bone: the chevron bones resemble those of the crocodile.

Fossil Turtles.—Waterworn bones of turtles are very common in the Purbeck strata, and several almost perfect examples of the carapace, or buckler, and of the plastron, or sternal-plates, have been discovered; a remarkably fine specimen from Purbeck, was exhibited many years since in Mr. Bullock's museum, in Piccadilly.

Fossil Fishes.—Detached angular scales of the well-known Wealden fish, the Lepidotus, are often met with in the clays and limestones: and many specimens of the entire fish, of a smaller species of the same genus (Lepidotus minor) have been obtained. The small hemispherical teeth, termed by the quarry-men fishes' eyes, are of very frequent occurrence in many of the beds. The slabs containing the Goniopholis, previously described, have numerous teeth and scales of the Lepidotus minor scattered among the bones.

The Portland Oolite.†—The series of sedimentary deposits, termed the oolite formation by English geologists, and known as the Jura limestone on the Continent, from the mountain-range in which it is so largely developed, consists of limestones, sands, and clays of great thickness and extent, which abound in marine shells, corals, crinoidea, articulata, and fishes—terrestrial and marine reptiles, insects, and land plants—and two or three genera of very small mammalia, referable to the marsupialia and insectivora. In this formation there are several local intercalations of fluviatile deposits, resembling the Wealden in the presence of terrestrial animals and plants, and freshwater shells.* Certain beds of the oolite (called the Stonesfield slate) contain organic remains, which, with the exception of trigoniæ and other marine shells, correspond with those of the Tilgate calciferous grits. The collocation of teeth and bones of the Megalosaurus, Lepidotus, &c., with stems and fruits of cycadeous plants, presented so striking an analogy, that it led me, on my first discovery of similar fossils in the Tilgate strata, to seek for the equivalent of the latter in the Stonesfield oolite.† In the Isle of Purbeck, the uppermost group of the oolite only appears; it is denominated "the Portland Oolite," from the island in which the limestone has for centuries been extensively quarried. This group is separated into three divisions, viz.: 1, the *Portland limestones;* 2, the *Portland sands;* and, 3, the *Kimmeridge clays,* so called, from the bay of Kimmeridge, where these beds are well displayed.

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* See "Fossils of Tilgate Forest," Pl. V. figs. 1, 2, 9.

† The term *Oolite*, or egg-stone, is derived from many of the limestones being composed of an aggregation of very small grains or spherules, which bear some resemblance to clusters of small eggs, or to the roe of a fish. This structure is merely concretional.

1. PORTLAND LIMESTONES.—Oolitic limestone, abounding in trigoniæ, ammonites, pernæ, plurotomariæ, and other marine shells; layers and nodular masses of chert and flint; total thickness, from 30 to 40 feet.

2. PORTLAND SANDS.—Beds of white and green sand and sandstone, with concretionary masses of grit; the lower strata argillaceous; total thickness, about 130 feet.

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* See "Wonders of Geology," vol. ii. p. 436.

† See "The Fossils of the South Downs," 1822, "On the analogy between the organic remains of the Tilgate beds and those of Stonesfield, near Oxford," p. 59.

3. KIMMERIDGE CLAY.—Dark blue clay, with septaria, and bands of sandy concretions; beds of lignite, and highly bituminous shales and clays; marine shells are very numerous; total thickness, 300 feet. One species of oyster, the *Ostrea deltoidea*, is characteristic of this group, and occurs abundantly in every locality.*

GEOGRAPHICAL DISTRIBUTION OF THE STRATA.—The White chalk forms a narrow but lofty chain of hills, that ranges inland across the island, from Handfast Point (section, lign. 28) to the cliff called Bat's Corner, on the southwestern shore. The lower cretaceous deposits appear along the southern escarpment of the downs; the chalk is also exposed to the east of Bat's Corner, in Worbarrow, or Worthbarrow Bay, and in several lesser bays or coves that have been excavated, by the long-continued action of the waves, in the Purbeck and Wealden deposits, that form the southern cliffs. The height of this chain of downs is from 500 to between 600 and 700 feet. Ballard Hill, over Handfast Point, is 584 feet, and Ninebarrow Down, 642 feet high. A line of chalk cliffs forms the coast from Bat's Corner to Whitenore (see lign. 36), where the cretaceous beds trend inland, and the cliffs beyond consist of the strata below the chalk. The Wealden and Hastings deposits extend entirely across the peninsula, from Swanage Bay to the southern shore at Worbarrow Bay, and form a valley, diversified with heaths and cultivated tracts, between the chalk escarpment and the next range. The Purbeck beds run in a nearly parallel direction with the Wealden, from the hills above Swanage, spreading out to the north as far as the village of Worth, and westward four or five miles, to the seashore on the south of Worbarrow Bay, and the adjacent coves.

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* Sowerby's "Mineral Conchology" contains figures of many of the shells of the Portland oolite; and in Dr. Fitton's Memoir, plates xxii. and xxiii., several species are figured and described.

The Portland group appears on the south-east beneath the Purbeck at Durlstone-head, and continues along the coast to Gad-cliff, constituting the regular tract that forms the south-eastern part of the Isle of Purbeck.

Southern Coast of Purbeck.—We must now take a rapid view of the most important features of the coast, from Durlstone-head to the western extremity of this interesting district. Swanage will be the most convenient place for the visitor desirous of exploring the geological phenomena of the eastern part of Purbeck; the numerous quarries in the vicinity, and the coast sections, being rich in organic remains. East and West Lulworth, two little villages near Worbarrow Bay, are the best halting-places for a survey of the south-western shores; and if the observer be tempted to extend his tour to the Isle of Portland, Weymouth, of course, will be the place of sojourn.

As the general dip of the strata is to the north, the lower beds are displayed along the southern coast; and we will now point out the most instructive localities, in proceeding from the south-eastern corner of the Isle of Purbeck, to the west.

Contorted Purbeck strata.—The strata in the middle and on the south side of Durlstone Bay, are very remarkable for their broken and contorted condition, which was evidently produced when the beds were in a plastic state. Septaria, veins of calcareous spar, and crystals of gypsum, occur in some of the clays; there are also masses of breccia, or conglomerate composed of fragments of the undulated layers, cemented together into a firm rock.*

To the west of Durlstone Head, the Portland oolite appears; and at Tillywhim (lign. 28) there are quarries for the extraction of the fine white limestone, here called Purbeck stone. These strata contain ammonites, trigoniæ, and the usual Portland shells, and veins and nodular masses of chert. A bed of oyster shells, which an infiltration of calcareous matter has converted into a hard shelly conglomerate, like that of Bromley, in Kent,* occurs in the upper part of the series. The quarries at Tillywhim are generally visited by parties in the summer, on account of the romantic character of the scenery, and the delicious cool retreat afforded by the caverns or excavations; these are reached by a path that winds through a deep valley, strewn with masses of stone, and the descent is by steps cut in the rock.† To the eastward there are similar caves, formed by the extraction of the layers of limestone: fine specimens of the oyster-shell conglomerate may be obtained from near the summit of the cliffs.

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* Mr. Webster has figured a mass o this kind in pl. xxxi. Sir H. Englefield's "Isle of Wight."

Lofty perpendicular cliffs of oolite, capped with Purbeck strata, continue along the coast to the west; and at the distance of about three miles from Tillywhim, the Portland stone is worked in Windspit quarries,‡ which are excavations in the cliff, like those at the former place.

About a mile to the west of Windspit quarries, the cliffs form a bold cape, called St. Adhelm's Head; and about midway between these places, the Portland sands emerge from beneath the oolitic limestones, and gradually rise towards the upper part of the cliff, as we proceed westward. The promontory of St. Adhelm's Head is a conspicuous feature of this part of the country, and is flanked by dangerous rocks, which have often proved fatal to mariners. It is a vertical section of the Portland limestone and sands, and of the underlying Kimmeridge strata; the former appearing at the top in immense square masses, and the latter below in a steep slope, covered by huge fallen blocks and fragments of stone. Deep fissures in the upper part of the cliff predict the impending ruin of other masses, and the agitation of the sea for above a mile from the shore indicates the nature of its rocky bottom; the remains, no doubt, of land which has been overwhelmed by the ocean. On the summit of this precipice are the remains of St. Adhelm's Chapel, a small building of early Saxon architecture, originally a chauntry, where masses were performed for the safety of the mariners that passed by this dangerous shore, who were expected to leave some gratuity at the first port they landed at, for the maintenance of the priest.*

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* See "Medals of Creation," vol. i. p. 385.

† A view of the cliff at Tillywhim is given by Mr. Webster, in Sir H. Englefield's "Isle of Wight," pl. xxxiii.

‡ Represented in pl. xxxii. of the same work.

From this point to Gad Cliff, which, in direct distance, is about six miles, the coast is much indented, and is flanked by cliffs of Kimmeridge clay, which are capped along the middle district by Portland sand and limestone; the total thickness of the clays is about 300 feet.

Rounding St. Adhelm's Head, the coast tends northward, and a creek, called Chapman's Pool, appears on the right; beyond is Emmett's Hill, a ridge nearly 300 feet high, capped with Portland stone, resting on the Portland sands, of which a good section is here exposed.† To the west, the cliffs for between two and three miles are, in a great measure, composed of highly bituminous shales, and laminated clays, termed "Kimmeridge coal;" we then reach Kimmeridge Bay, an excavation formed by the sea, in the low tract of fissile argillaceous deposits which constitutes this part of the coast. The view of Gad Cliff from Kimmeridge Bay is very imposing, for in the foreground the black bituminous clay cliffs run out into a low point, and, towering over them to the westward, the limestone summit of the distant hill is distinctly visible. The bay is partly encircled by an amphitheatre of high ground, the summits of which consist of Portland stone, the steep grassy slopes being composed of the Portland sands, resting on the Kimmeridge clays. Thus, then, the three divisions of the Portland oolite, as exhibited in the Isle of Purbeck, may be traced from Emmett's Hill, which is about 250 feet high, by the prominence called Encombe Point, through Kimmeridge farm to beyond Gad Cliff, where they sink beneath the sea at Worbarrow Knob, on the eastern side of the headland of Purbeck beds, that forms the southern point of Worbarrow Bay.* The Kimmeridge clay reappears in Ringstead Bay, between seven and eight miles beyond Gad Cliff, to the west of the chalk at Whitenore; thence to Weymouth, the lower beds of clay become charged with sand and calcareous earth, and pass insensibly into the limestone strata of the Oxford oolite.

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* Mr. Webster.

† See Dr. Fitton's "Memoir," p. 211.

KIMMERIDGE COAL.—The strata in the immediate vicinity of the place from which the name of the group is derived, are composed of bituminous fissile shales and laminated clays, alternating with thin courses of brown limestone. As some of the layers are so largely charged with carbonaceous and bituminous matter as to be used for fuel, the most combustible beds of these substances are commonly known as the Kimmeridge Coal.† "This coal," observes Mr. Webster, "is merely a slaty clay, strongly impregnated with bitumen, and does not exhibit any signs of vegetable structure. It burns very readily with a brisk flame, affording a good heat, but emitting a very disagreeable smell."*

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* Principally from Dr. Fitton's "Memoir" and sections; my own observations along this part of the coast have been very limited.

† At Chilley, in Sussex, sandstone strongly impregnated with bitumen (called "pitchstone" by the neighbouring peasantry), and much resembling in appearance some of the Kimmeridge beds, is found beneath the silt in Pevensey levels. It is described in "the Fossils of the South Downs," p. 76. I have not been able to examine this bed *in situ;* it probably belongs to the Wealden formation.

Beneath the bituminous beds, are clays, shales, and thin bands of limestone, containing the *ostrea deltoidea, ammonites triplex, gryphea virgula*, and other shells characteristic of this division of the oolite formation.

SOUTH-WEST COAST OF PURBECK.—We have now arrived at that part of the coast, where the range of vertical chalk, of which we examined the eastern extremity at Handfast Point, appears in the inland recesses of several little bays or coves, which the sea has excavated along this shore; nine sections of the beds between the chalk and the Portland oolite being exposed, within a distance of five miles. The Wealden, Purbeck, and Portland strata, which on the south-eastern coast form on the south of the chalk downs a tract of country of considerable breadth, are here diminished to one-third of a mile, or even less; so that in the space of a few hundred yards, the entire series may be examined; for the strata so rapidly converge to the westward, "that the total distance from the top of the greensand to the beginning of the Portland oolite, which is about two miles and a half between Ballard Downs, and Durlstone Head, is but 150 paces in Durdle Cove."†

The plan of the coast, lign. 31, from the western end of Worbarrow Bay to Whitenore, shows the situation of the bays we are about to examine. The "Swine's Back"

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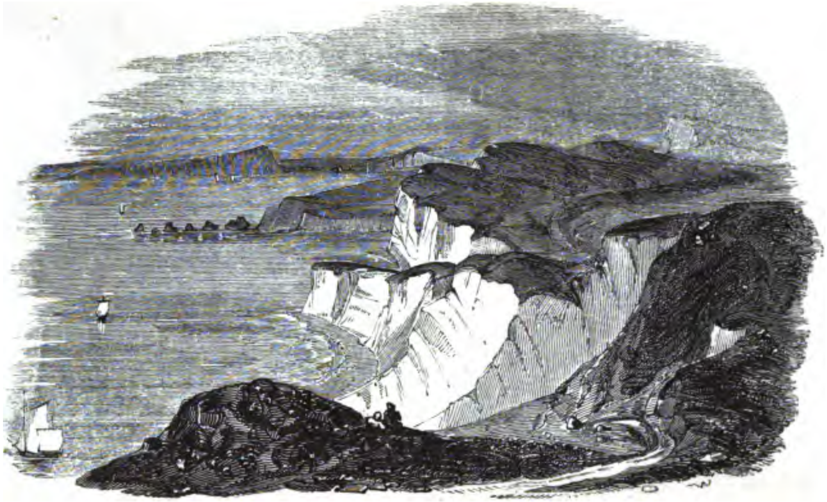
* Sir H. Englefield's "Isle of Wight," p. 187. I may here notice that there are often found at Kimmeridge, Encombe, and the surrounding neighbourhood, circular pieces of shale which have evidently been turned in a lathe. They are of the size of a half crown, and have a few circles drilled partly through on one side. They are termed by antiquaries "*coal-money*," and are supposed to have passed as tokens in ancient times—perhaps they were current only in the peninsula. Several are occasionally found carefully buried beneath two stones.

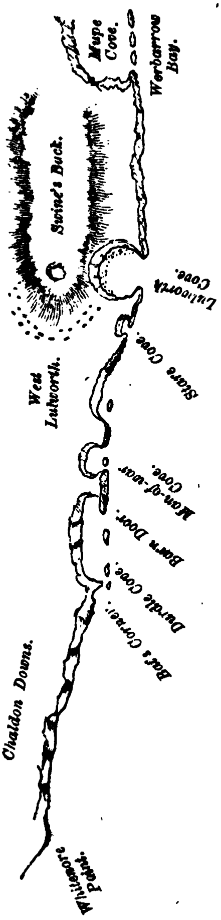
† Dr. Fitton.

Pl. XVI.



VIEW OF THE DORSETSHIRE COAST FROM THE SUMMIT OF WORBARROW HILL; LOOKING WESTWARD.

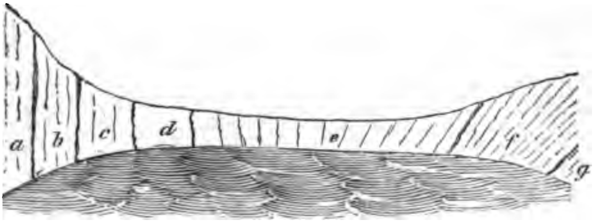
is part of the lofty range of chalk downs, which, interrupted here and there by deep valleys, in one of which the village of West Lulworth is situated, continues westward to Chaldon Downs, forming the inland barrier of the Coves, and the line of cliffs from Bat's Corner to Whitenore Point. The scenery in this part of the peninsula is highly picturesque, whether viewed from the sea, or from the summits of the downs. A magnificent view of the Dorsetshire coast is obtained from a tumulus on the brow of a very lofty precipice of chalk, that overhangs Worbarrow Bay. It is admirably represented in plate 35, of Sir H. Englefield's work; Pl. XVI. is a slight sketch of the same. From this height we look across the bay to the westward; the path down to the shore is seen beyond the projecting point of the chalk cliff. The detached rocks in the sea are of Portland stone, and mark the western boundary of the bay; the low cliffs are Purbeck and Wealden strata. The hill in the middle of the landscape



LIGN. 31.—THE SOUTH-WEST COAST OF THE ISLE OF PURBECK, FROM MUPE COVE IN WORBARROW BAY, TO WHITENORE POINT. (*The distance about five miles.*)

is the Swine's Back, beyond which is Lulworth Cove; the Isle of Portland appears in the remote distance. The deep sinuosities made in the cliffs by the inroads of the sea are very conspicuous from this elevated position, and the physical characters of the district, produced by its geological structure, are well displayed. The height on which we are standing, is the sudden termination of the vertical chalk range which appears in the section at Handfast Point; and we can trace the chalk downs extending four miles further westward, in the line of sea-cliffs beyond the coves. Thus in the Isle of Wight, the chalk cliffs at Freshwater appear to the west of the Wealden strata of Brook and Compton Bays (p. 155); and should the sea continue to encroach on that part of the coast of the "beautiful island," the chalk would at length be reached, and form the inland barrier of a semicircular bay, bounded on the sides by the lower cretaceous deposits, and on the south by Wealden strata; as in the coves of Purbeck.

To the south, the chain of hills composed of Purbeck and Portland beds appears; and the intermediate tract is a fertile valley, formed by the Wealden clays, and sands. Thus the northern barrier of the coves consists of precipitous chalk cliffs, the entrance is formed by rocks of the Portland and Purbeck limestone, and between these, is a low coast,



LIGN. 32.—PLAN OF THE STRATIFICATION OF THE COVES ON THE SOUTH-WESTERN COAST OF THE ISLE OF PURBECK.

a, Chalk. *b*, Chalk-marl. *c*, Firestone. *d*, Galt. *e*, Wealden. *f*, Purbeck. *g*, Portland oolite.

composed of the less durable strata of the Wealden. These bays expose, in fact, transverse sections of the hills of Portland and Purbeck strata—of the clays and sands of the Wealden—and at their back, chalk precipices of great height, formed by the destruction of the southern face of the Downs.

The plan of the stratification, lign. 32, given by Mr. Conybeare,* affords a clear illustration of this structure. The Portland and Purbeck beds (*g*, *f*,) dipping inland, in an angle of from 45° to 60°, form the outer capes and reefs—the vertical cretaceous strata (*a*, *b*, *c*, *d*,) the inland cliffs; and the Wealden (*e*), the intervening portion. The latter in many of the sections, have the same contorted appearance as in the cliffs on the south of Durlstone Bay. The solid layers of sandstone and limestone, though broken, preserve regular planes of stratification, having from their compactness resisted the violence of the movements to which they have been subjected; but the superincumbent plastic argillaceous beds have been bent into irregular curves, by lateral pressure. Hence too the peculiar form of the coves; for the firm barrier of Portland stone, being only partially broken through, scarcely more than one-third of the circumference of these bays is open to the sea.

WORBARROW BAY.—On the south side of Worbarrow Bay, the junction of the Hastings sands of the Wealden with the Purbeck strata, is visible, and Dr. Fitton has described the following section, which was observable at the time of his visit; from the crumbling nature of the cliffs, a clear view of the beds is not always attainable.

Grey and yellow sand, occupying on the shore, thirteen paces.

A space concealed at the top; where visible the beds consist of clay, with lignite; concretions of quartzose grit with cyclades. At the bottom, nine paces.

Beds containing stone, with small paludinæ cemented together by green calcareous earth; called "marble," and "marble-rag," by the quarry men; sixteen paces.

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* "Geology of England and Wales," p. 183.

About twenty-five paces more of the cliff are made up of brown and grey clays, with bands of bluish grit, and thin beds of stone.

Contorted clays and limestones, which extend to the prominence called Worbarrow knob. Between this point, and Gad Cliff on the east, a thickness of fifty feet consists of alternating layers of clays and limestones, which are also much undulated.

On the west side of Worbarrow Bay, low insulated masses of Purbeck rocks appear on the shore. In crossing this bay in a boat, a fine view of the lofty chalk cliff is obtained; and through the valley in the centre of the cove, Lulworth Castle forms a striking object in the distance. At a spot in this bay called Arish-mel, vertical chalk and flint strata, as at Handfast Point, are well displayed.

LULWORTH COVE.—The picturesque scenery of this part of the Dorsetshire coast was well known to tourists, and the little village of West Lulworth, which is charmingly situated in a deep chalk valley, was a frequent resort of water-parties from Weymouth, during the summer, ere its attractions were heightened by the discovery that the geology of the country is in the highest degree interesting. West Lulworth, of which a sketch is given in Pl. XVIII. (p. 277), is about two miles west of Lulworth Castle, and a quarter of a mile from the cove. The hill immediately above the village in this view, is the western termination of the chalk downs, called the Swine's Back (see lign. 31, p. 269), which is cut into by the cove, and forms a precipitous chalk cliff in the middle of the bay. The nearest headland seen beyond the cove is Gad Cliff; that in the remote distance is St. Adhelm's Head.*

Lulworth Cove is about 1300 feet across, and is of sufficient depth for vessels of above a hundred tons burden

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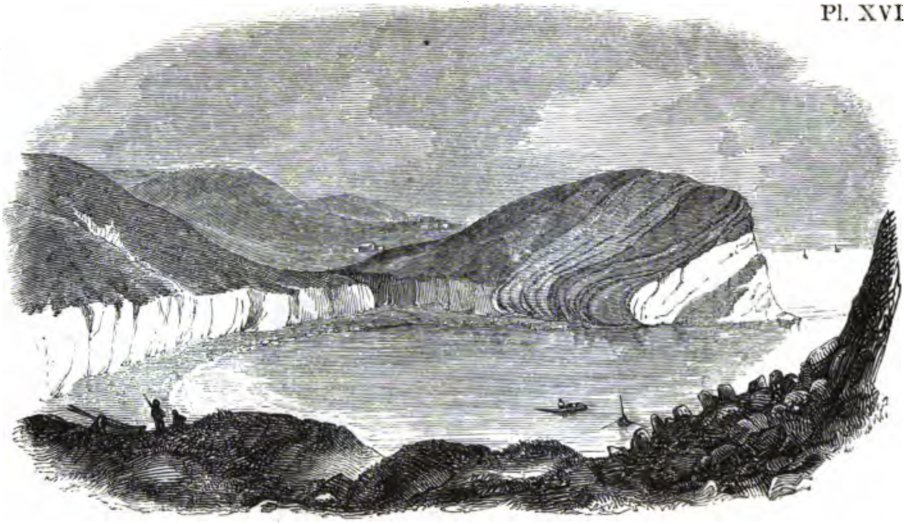
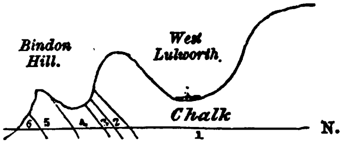
* Boats may be obtained at Lulworth and Worbarrow for excursions along the coast.

Pl. XVII.



LULWORTH COVE, FROM THE WEST.

to remain at all times in perfect shelter and security. A copious and transparent spring bursts out from a cavern just below the village, and after turning a mill, flows into the bay. The rock from which the water issues, is composed of sharp fragments of flint imbedded in chalk rubble, cemented together by stalactitical deposition.

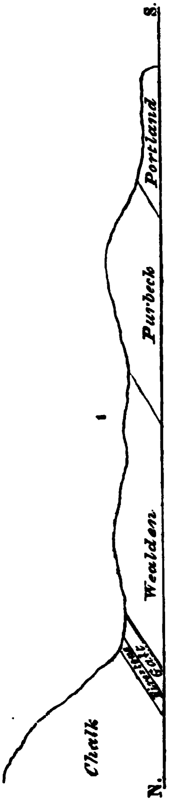


LIGN. 33.—PLAN OF THE STRATA ON THE WEST SIDE OF LULWORTH COVE.

1. Chalk. 2. Firestone. 3. Galt.
4. Wealden. 5. Purbeck. 6. Portland stone.

The cliffs around this semicircular basin present the same section as those in Worbarrow; the entire series of strata, from the chalk to the oolite, being clearly exposed. The plan, lign. 33, explains the relative position of the deposits, as seen on the west side of the bay. On the east side, a similar section occurs, as represented in lign. 34; and the chalk, firestone, galt, Wealden, Purbeck, and Portland beds, are seen in their natural order of superposition, in a distance of between five and six hundred yards, proceeding from north to south.

A view of this part of the bay, from the west, is given, Pl. XVII. In this sketch a small portion of the base of the chalk downs is visible on the left; the low cliffs that succeed and wind round the middle of the bay, are the lower cretaceous strata, and the clays and sands of the Wealden. The headland at the entrance of the cove, consists of contorted Purbeck beds, resting on the Portland oolite, of which large masses project on the shore. The appearance of the undulated layers of Purbeck limestone is very striking in the weathered portions of the cliff, from the intermediate clays having been worn away, and the bands of stone left prominent. The blocks on the right, in the foreground, are of Purbeck limestone, and extend towards those that form the opposite bar.



LIGN. 34.—SECTION OF THE EAST SIDE OF LULWORTH COVE. (*Dr. Fitton.*)

Dr. Fitton, with characteristic accuracy and minuteness of detail, has given measurements of the spaces occupied by the different groups of strata below the chalk in Lulworth Cove. The firestone and galt are about 150 feet; the Wealden beds, 600 feet; the Purbeck, 450 feet; and the Portland, 240 feet. The fossils here met with are lignite, and a few paludinæ and uniones, in the Wealden; and in the Purbeck, shells of the same genera occur in layers, and mussel-shells abundantly in a coarse green sand-rock, as at Durlstone Head.

FOSSIL TREES.—Seams of lignite are numerous in the Wealden sands and clays, as in Swanage Bay, and in Brook Bay, in the Isle of Wight. In the Portland strata, a little way to the eastward, are petrified trees, still attached to the soil in which they grew. These were first observed by the present Dean of Westminster, and Sir H. De la Beche.* The sketch in lign. 35, copied from the "Memoir on the

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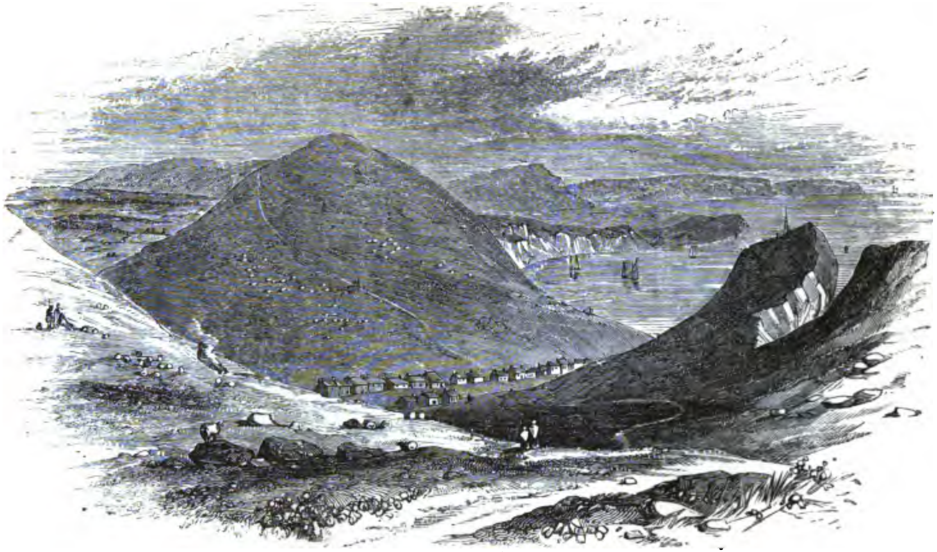
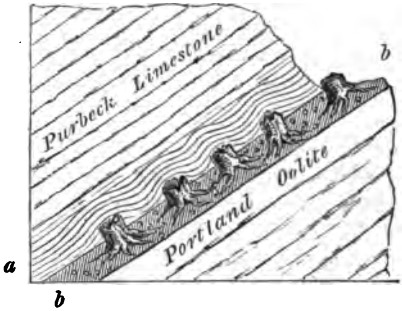
* "Geological Transactions," vol. iv.

Pl. XVIII.



WEST LULWORTH AND COVE; FROM THE WEST.

Geology of Weymouth," by these distinguished geologists, illustrates the position of the strata and fossil trees.



LIGN. 35.—SECTION EXPOSED IN THE CLIFF EAST OF LULWORTH COVE.

a, *a*. Stratum of calcareous laminated stone, termed "*burr*."
b, *b*. The "*dirt-bed*," with fossil trees.

(*From the Geological Transactions.*)

On doubling the rocks on the east corner of the cove, the Purbeck beds are seen resting on the oolite, and forming South Cliff, which is surrounded by the insulated masses of rock that appear on the west side of Worbarrow Bay. (See Pl. XVI., p. 268.) It is about a furlong to the east of Lulworth Cove, in the highly inclined strata of the cliff, that a considerable number of petrified trunks of trees are exposed. Some are entirely laid bare by the washing of the sea, and others partly so; but several are almost wholly encased by concretions of soft burr-stone, and have their roots fixed in a layer of black earth (termed "dirt-bed" by the quarrymen); in precisely the same relative position, and interspersed with similar rounded fragments of limestone, as in the fossil forest of the Isle of Portland, hereafter noticed.

The lowermost strata are the Portland oolitic limestones, full of marine shells; on them is superimposed the layer termed the "dirt-bed," with the fossil trees. This is covered by cream-coloured calcareous stone disposed in very thin undulated laminæ, and locally termed "soft burr;" and above are shales, and thin bands of limestone, belonging to the lowermost beds of the Purbeck.

There are also layers of chert containing chalcedonic casts of freshwater shells, in the cliff just above the sea level.*

DURDLE, OR BARN-DOOR COVE.—There are several smaller bays, which are worth examining if the visitor's leisure will permit: these are Mupe Cove, which is situated in Worbarrow Bay (see lign. 31, p. 269); Stare Cove,† near Lulworth; and Man-of-War Cove, half a mile further to the west, so called from a long rock at the entrance, named the Man-of-War. In each of these bays the same geological phenomena are observable. They may all be approached from the land, but are seen and studied to most advantage from the water.

Durdle, or Barn-door Cove, is remarkable for a natural perforation or archway, formed by the waves in a projecting crag of the nearly vertical Portland oolite, which bounds the eastern cape of the bay. This arch, commonly called the Barn-door, is large enough to admit the passage of a boat with the sails up; and in very fine weather it is customary for the pleasure parties from Weymouth to sail through it. The western cape of the bay is composed of vertical strata of chalk and flint, and is called Bat's Corner. (See lign. 31, p. 269). This bay, therefore, differs from those above described, in presenting but one section of the

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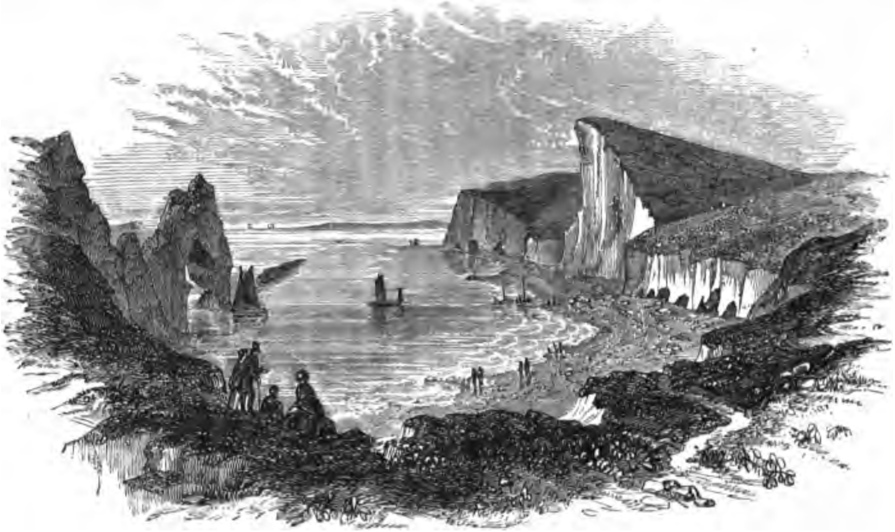
* On the hills near Lulworth there are detached blocks of the Hertfordshire siliceous pudding-stone lying upon the chalk; and large masses of this conglomerate may be seen in the street of West Lulworth, and in the walls of some of the cottages.

† Stare Cove—so called from several caverns through which the sea dashes with a loud roar. In this cove the contortions of the Purbeck beds are very grotesque and remarkable. Pl. xliv. of Mr. Webster is a fine view of this little bay.

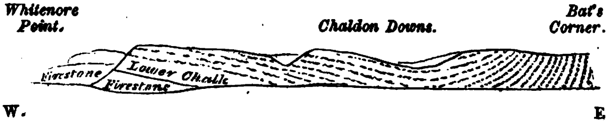
Pl. XIX.



DURDLE COVE, FROM THE INLAND CLIFFS.

strata, which, commencing with the chalk on the west, and succeeded by the lower groups, terminates in the Portland oolite on the east. The view by Mr. Webster (see Pl. XIX.) admirably illustrates the geological structure of this beautiful bay. In this sketch the chalk appears on the right, forming the high cliff on the western cape, termed Bat's Corner; in passing thence, the firestone, galt, Wealden, and Purbeck strata, successively appear, and lastly the Portland rocks, which terminate the point on the left of the view, as indicated by the archway called the "Barn-door." A line of low oolitic rocks stretches across the mouth of the bay.

CHALDON DOWNS.—Proceeding to the westward we lose all traces of the beds below the chalk; the chalk cliffs, which are between 200 and 300 feet high, form the western headland of Durdle Cove, and continue along the coast to Whitenore Point, the eastern cape of Weymouth Bay, a distance of about two miles (lign. 36,); these strata present some interesting features. In these cliffs, the gradual transition of the chalk beds from a vertical to a gently inclined position, is clearly shown. The vertical strata at Bat's Corner, partake of the same characters as those at Handfast Point; the chalk being much indurated, and the flints shattered. A quarter of a mile to the west the layers of flint are nearly horizontal, being united with



LIGN. 36.—CHALK CLIFFS, ON THE SOUTH-WEST COAST OF THE ISLE OF PURBECK FROM BAT'S CORNER TO WHITENORE POINT.

(The Rev. W. D. Conybeare.)[*]

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[*] "Geology of England and Wales."

the vertical by a gentle curve, as shown in lign. 36; and in these beds the chalk possesses its original friable texture, and the flints are entire. Towards Whitenore the firestone and galt appear at the base of the cliffs. At this spot the chalk trends inland, and thence to Weymouth the coast is flanked by cliffs and flat shores of the inferior strata. From the summit of the chalk cliff at Whitenore, which is about eight miles E.N.E. of Weymouth, the view to the west shows numerous little bays, hollowed out of the shore by the action of the sea along the coast, as far as Weymouth, and Portland island is strongly defined on the horizon over the sea. To the eastward are seen the chalk cliffs extending to Bat's Corner, and the projecting capes of Durdle and Lulworth Coves, and the summit of Worbarrow Down.

RINGSTEAD BAY.—To the west of Whitenore, the Kimmeridge clay, which we lost sight of at Gad Cliff (see p. 264), re-appears in Ringstead Bay, and a good section of the strata is exposed in the cliff. Proceeding towards Weymouth, the clays in the lower part of the series gradually become sandy and calcareous, and pass insensibly into the Oxford oolite.

In Ringstead Bay, there is a striking example of that kind of displacement, which is geologically termed a fault; signifying a vertical or diagonal fissure through the strata, accompanied either by a subsidence, or an upheaval, of one side of the dislocated masses. In this instance the beds, consisting of chalk, firestone, and oolite, on the south side of the fissure, are thrown down much lower than those from which they have been separated. This phenomenon is connected with the displacements which the districts we have passed over have undergone. The line of disturbance we traced through the Isle of Wight, forming the anticlinal axis from east to west, continues through the Isle of Purbeck from Swanage Bay to Lulworth Cove and the adjacent bays, and is prolonged westward through the vale of Weymouth, to the Chesil Bank; the strata dipping respectively north and south, on each side the principal axis of elevation. The transverse valleys which here and there intersect the chain of hills, have no doubt originated from fractures occasioned by the tension to which the strata were subjected during their elevation, by the expansion of elastic vapours, or heated erupted rocks, far beneath the surface. For Mr. Hopkins has shown, on mathematical principles, that tabular masses of rock elevated by a force from below, must have been exposed to two sets of tension, which would produce longitudinal and transverse vertical fractures at right angles to each other; and the direction of the principal fissures, or lines of fracture, in the tracts or country we have surveyed, remarkably coincides with this theoretical deduction.

PSEUDO-VOLCANO.—A circumstance connected with the bituminous property of the Kimmeridge clay, which happened in Ringstead Bay, some years since, may here be mentioned. In September, 1826, at Holworth Cliff, and adjacent to the promontory of Whitenore, a spontaneous combustion of the bituminous shale occurred, and burst forth with considerable volumes of flame, and exhalations of sulphureous vapours. It continued smouldering for many years, and the surrounding clay and shale were burnt into cellular slag. This combustion probably originated in the heat produced by the decomposition of pyrites, with which the strata abound.*

The cliff in Ringstead Bay is rich in the usual fossils of the Kimmeridge beds; and Osmington Cliff, west of Ringstead, abounds in trigoniæ and other shells of the Oxford clay, many of which are in a beautiful state of perfection. Crystals of sulphate of lime, or selenites, are common in the clays.

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* See the Memoir on the Geology of Weymouth, &c. "Geol. Trans." vol. iv.

The Isle of Portland.—Though beyond the limits originally prescribed to these excursions, the Isle of Portland, which we have seen looming in the western horizon during the greater part of our progress from the Isle of Wight, is so intimately related in its physical structure with the country over which our observations have extended, that some notice of that interesting spot is necessary, to afford a comprehensive view of the geological phenomena, which this volume is designed to illustrate.

The Isle of Portland is a bold headland on the south of Weymouth, about four and a-half miles in length, and two in breadth, united to the mainland by a bar of shingle termed the Chesil Bank. It presents a precipitous escarpment on the north about 300 feet in height, and declining towards the south, appears, when viewed from the east or west, like an insulated inclined plane rising abruptly from the sea. The substratum or foundation of the island, consists of the Kimmeridge clay, which attains a considerable elevation on the north; this is surmounted by beds of Portland sands, and thick strata of the oolitic limestone so well known as the Portland stone, which is extensively worked in numerous quarries. The strata dip to the south at an angle which corresponds with the profile of the island. The coasts are steep, the base of Kimmeridge clay forming a talus surmounted by perpendicular crags of oolite; in the north-east cliff, there are beds of bituminous shale like those in Ringstead Bay. The southern extremity consists of low limestone cliffs, which are worn into numerous caverns by the force of the waves.

The summit of the northern brow, to a depth of upwards of twenty feet, is formed of a series of freshwater strata superimposed on the uppermost bed of oolite, which is locally termed "the Cap." These belong to the Purbeck, and present the same remarkable phenomena as were observed in the cliff to the east of Lulworth Cove. (See

p. 279.) Mr. Webster first directed attention to the highly interesting facts here disclosed.

The Kimmeridge clays of Portland resemble those we have examined in Ringstead Bay, and in the Isle of Purbeck. The lower beds of oolitic limestone immediately above the clay, contain nodules and veins of flint and chert, like those at Durlstone Head; the middle group is full of trigoniæ, terebræ, cythereæ, ammonites, and other characteristic marine shells of the oolite; and the upper series, to within twenty feet of the surface, consists of the fine architectural stone which is locally termed "the white-bed." Upon this are three or four feet of limestone, full of cavities left by a layer of shells, of which the casts only remain; and above, is an irregular bed of flint nodules, covered by a thin stratum of earthy oolitic detritus. Beautiful yellow sulphate of barytes, called sugar-candy-spar, and stalactites of calcareous spar, occur in the fissures of the limestone.

THE PETRIFIED FOREST.—Upon the uppermost oolitic stratum, is a layer a foot thick, of very dark brown friable loam, which appears to have been a bed of vegetable mould. It contains a large proportion of earthy lignite, and like the modern soil on the surface of the island, waterworn stones, and pebbles. This layer is called the "dirt-bed" by the quarrymen, and in and upon it are stems and branches of coniferous trees, and plants allied to the cycas and zamia. Many of the trees and plants are standing erect, as if petrified while growing undisturbed in their native forests. Their roots extend into the soil of the dirt-bed, and their trunks into the superincumbent strata of limestone.*

As the Portland building stone lies beneath these beds, and the Cap is only used for lime, the fossil trees are removed and thrown by as useless, and the dirt-bed cleared away, to arrive at the more valuable material. On one of my visits to the island, the surface of a large area of the dirt-bed was exposed, preparatory to its removal, and the appearance presented by the fossil trees was most striking. The floor of the quarry was literally strewn with fossil wood, and before me was a petrified forest, the trees and the plants, like the inhabitants of the city in Arabian story, being converted into stone, yet still remaining in the places they occupied when alive! Some of the trunks were surrounded by a conical mound of calcareous earth, which had evidently, when in the state of mud, accumulated around the stems and roots. The upright trunks were in general a few feet apart, and but three or four feet high; they were broken and splintered at the top, as if the trees had been snapped, or wrenched off, at a short distance from the ground. Some were two feet in diameter, and the united fragments of one of the prostrate trunks, indicated a total length of between thirty and forty feet. In many examples portions of branches remained attached to the stems. The external surface of all the trees I examined was weatherworn, and resembled that of posts and timbers of groins and piers within the reach of the tides, and subjected to the alternate influence of the water and the atmosphere. There were no vestiges of the bark in a carbonised state, nor of the natural external surface of the stems, as in the prostrate trees at Brook Point in the Isle of Wight. (See p. 206.)*

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* The diagram of the fossil trees in Lulworth Cove, p. 279, if placed with the lines of stratification in a horizontal position, will serve to illustrate this description.

The cycadeous plants occur in the intervals between the trees, and the dirt-bed is so little consolidated, that I dug up with a spade several specimens that were standing erect, in the position in which they originally grew. These plants, though related to the cycadeæ (p. 212), are referred by M. Adolphe Brongniart to a new genus, which he has named *Mantellia.* There are two species; one is short, and of a spheroidal form (*M. nidiformis*); the other is longer, and sub-cylindrical (*M. cylindrica*): the specimens of the former species are called "Crows' nests" by the workmen, who believe these plants to be bird's nests, originally built by crows in the fossil trees, which have become petrified. The largest specimens are about two feet high, and three feet in circumference.*

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* In the Botanic Gardens in the Regent's Park, there are several magnificent specimens of the Portland trees, with the trunks remaining upright in the mounds of stone, and the silicified roots extending into the bituminous rubble of the dirt-bed. They are placed near the foot of the artificial mount in the pleasure grounds. A great part of the stone-work of the cascade in the Colosseum in the Regent's Park, is constructed of fragments of the fossil wood of Portland.

The pine trees and the mantelliæ are completely silicified, and their internal structure is beautifully preserved in many examples; the wood, when microscopically examined, displays the araucarian structure. (See p. 206.) A cone has been found in the dirt-bed, which Dr. Brown considers to be closely related to the fruit of the Norfolk Island Pine (*Araucaria excelsa*).† The Portland and Isle of Wight fossil coniferæ appear to belong to one species.

Above the dirt-bed are layers of finely laminated cream-coloured limestone, the total thickness of which is about ten feet; in these beds I have not discovered any traces of organic remains, but Dr. Fitton mentions the occurrence of casts of cyprides. These strata are covered by the modern vegetable soil, which but little exceeds in depth the ancient one above described, and instead of supporting cycadeous plants, and pine-forests, barely maintains a scanty vegetation, there being scarcely a tree or shrub on the whole island.

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* These fossil cycadeæ are admirably illustrated by Dr. Buckland in "Geol. Trans." vol. ii. new series; and also in his "Bridgewater Essay." A fine suite of specimens, formerly in my collection, is exhibited in the British Museum.

† Dr. Fitton.

There is a seam of black earth at the distance of five feet, and another two feet lower, beneath the dirt-bed, indicating two short intervals during which vegetable matter had begun to accumulate on the surface of the uppermost beds of Portland stone, when they were first emerging above the level of the sea. In these layers Dr. Fitton observed remains of cycadeous plants.*

The dirt-bed extends through the north of Portland, and appears, as we have seen, on the coast of the peninsula of Purbeck. It has been discovered by Dr. Buckland near Thame, in Oxfordshire, and by Dr. Fitton, in the Vale of Wardour. It also occurs at Swindon, Wilts, where fossil coniferous wood abounds, and some specimens of cycadeæ have been obtained; and between Stone and Hartwell, where it is covered by cream-coloured freshwater limestone, resembling the Cap of Portland, in which wings of insects, and leaflets of the Wealden ferns, have been discovered by the Rev. P. B. Brodie,† and my friend, the Rev. J. B. Reade, Vicar of Stone. In the tertiary freshwater beds at Binstead (see p. 74), there is a stratum of bituminous earthy loam, so like the dirt-bed, that it seems probable it may have had a similar origin, and be the remains of a layer of vegetable mould.

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* See "Wonders of Geology," vol. i. p. 362. For a detailed account of the Portland quarries, and the phenomena concisely described in the text, consult Dr. Fitton's "Memoir;" and Dr. Buckland and Sir H. De la Beche on the Geology of Weymouth, "Geol. Trans." vol. iv. second series.

† See the highly interesting work of Mr. Brodie, entitled, "A History of the Fossil Insects in the Secondary Rocks of England," 1 vol. 8vo., with 10 plates, published by John Van Voorst, 1845. Mr. Brodie has discovered numerous remains of small insects, belonging to forty-eight families and genera, in the Wealden strata of Wilts and Bucks. I have not been so fortunate as to detect any vestiges of Insects in the Wealden of the Isle of Wight and Sussex; but I have two or three wings of small beetles, from Kent, and of neuropterous insects from near Stone, in Buckinghamshire.

ORGANIC REMAINS.—The common species of marine shells, already mentioned as characteristic of the strata below the Purbeck, occur more or less abundantly in the several localities previously mentioned. In the Portland stone, one species of ammonite, of a very large size, hence named *Ammonites giganteus*, is often met with, and good specimens may be procured of the quarrymen. The fossil wood is to be found in most of the stone quarries, and the cycadeous plants, called *Mantelliæ*, may be purchased of the workmen, to whom they are known as "Crows' nests."*

I am indebted to Mr. Damon, of Weymouth,† for the following notice of localities, which may afford useful hints to visitors:—

Ringstead Cliff.—From the Kimmeridge clay, Mr. Damon has obtained specimens of *Pholadomya, Terebratula, Trigonia, Modiola, Ostrea deltoidea, Mya, Pleurotomaria, Phasianella, Ammonites triplex, A. Gowerianus*, &c.

Whitenore.—In the chalk marl, near the base of the cliff, after recent falls, may be collected specimens of *Ammonites, Turrilites, Scaphites, Baculites, Terebratula, Pleurotomaria, Natica, Buccinum*, and several kinds of *Echinites*. The white chalk is not rich in organic remains.

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* At the little village of Chesilton, which is inhabited by some of the quarrymen, I have always been able to purchase specimens. Should the visitor wish to obtain a considerable length of the stem of a tree, with branches attached, it may be well to caution him to beware of imposition. A specimen, sent to me as an entire trunk, was made up of disconnected portions of stems and branches, belonging to several trees, ingeniously fitted and cemented together.

† A fine collection of recent, as well as fossil shells, properly named, may be purchased at Mr. Damon's establishment at Weymouth; also most of the rare species of fossils from the neighbourhood.

In London, fossils from the localities mentioned in the text, properly named, as well as specimens of other British fossils, &c., may be obtained, at moderate prices, of Mr. Henry Stutchbury, 61, Great Russell Street, opposite the British Museum, and of Mr. Tennant, 149, Strand.

At Osmington, two miles west of Whitenore, the firestone rests on Kimmeridge clay, and contains *Exogyra conica*, *Pecten quinquecostatus*, *Cucullea*, *Serpula*, Sharks' teeth, &c. The Kimmeridge clay yields beautiful *Trigoniæ*, *Ostrea deltoidea*, &c.

On the shore opposite Weymouth, between Redcliff and Osmington, the Oxford oolite abounds in shells belonging to upwards of twenty genera.

On the south side of Weymouth, a quarter of a mile east from Sandfoot Castle, the Coral-rag is full of shells and corals. A fine spiral univalve, the *Nerinea Goodhalli* ("Geol. Trans." vol. iv. pl. xxxiii. fig. 12), is found here.

Near Black-rock, half a mile from Weymouth, the Oxford clay abounds in fossils, which can, however, only be procured by digging through a bed of alluvial soil, two feet thick.

The upper bed of Portland oolite, called the "Roach," is a congeries of casts of *Trigoniæ*, *Pernæ*, *Terebræ*, *Ammonites*, *Lucinæ*, &c. Scales and teeth of a species of *Lepidotus* are sometimes found in the Portland stone.

Magnificent *Septaria*, veined with calcareous spar, are found in the Oxford clay, and are cut and polished for tables, slabs, &c.*

With this brief account of the Isle of Portland and its petrified forest, these Excursions must terminate. To the geologist, this unpretending volume will, I fear, present but little of novelty or interest, and probably be useful only as a guide to the most important localities; but to the general reader, who may be induced to visit and explore the "beautiful Island," and the picturesque scenes described in the preceding pages, I would fain hope that it may prove a source of pleasure and instruction, by opening to his mind new and inexhaustible fields of inquiry, replete with objects of surpassing interest, and which the uninformed and incurious tourist would pass by unnoticed or disregarded.

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* A fine collection may be seen at the establishment of Mr. Ragget, Statuary, on the South Parade, Weymouth.

RETROSPECT.

In attempting to interpret the natural records of the earth's physical history, the geologist is often in the condition of the antiquary who endeavours to decipher an ancient manuscript, in which the original characters are obscured and partially obliterated by later superscriptions. It is, indeed, frequently difficult, and sometimes impossible, to determine the synchronism of those geological changes, of which the only indications are insulated and but obscurely related phenomena. Bearing in mind the caution of a distinguished philosopher,* "that the language of theory can never fall from our lips with any grace or fitness, unless it appear as the simple enunciation of those general facts with which by observation alone we have become acquainted," we will take a retrospective view of what has been advanced, and endeavour to deduce therefrom some general results as to the nature of those physical mutations, of which we have obtained such unequivocal proofs. Fortunately, the evidence of the important changes which the organic and inorganic kingdoms of nature have undergone in this part of the globe, during the vast periods embraced by our researches, is so conclusive, that the attentive reader will perceive the following inferences, startling as they may appear, naturally result from the facts that have been submitted to his observation.

I. The Oolitic Epoch.—The most ancient deposits comprehended in our Excursions, are the uppermost beds, of an oceanic formation of great extent—the *oolite*—which is characterised by numerous peculiar species and genera of marine reptiles, fishes, mollusks, radiaria, corals, zoophytes, &c. With these strata are intercalated in some places, deposits of variable extent and thickness, containing carbonised vegetable remains, and the stems and foliage of palms, arborescent and herbaceous ferns, cycadeous plants, and coniferæ; with bones and teeth of terrestrial reptiles, and of marsupial and insectivorous mammalia, associated with vestiges of insects. These beds are evidently attributable to the action of rivers and streams, by which the spoils of the land were transported into the abyss of the ocean. But our present survey only refers to the period when a portion of the bed of the oolitic sea was elevated above the waters, and constituted an island clothed with pine forests, and cycadeous plants.*

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* Professor Sedgwick.

II. THE WEALDEN EPOCH.—The country with its pine-forests was gradually submerged, and formed the beds of estuaries and bays, into which land floods, loaded with sedimentary detritus, deposited mud, silt, and sand, abounding in the remains of freshwater mollusks and crustaceans; in which, from occasional irruptions of the sea, were intercalated layers of oysters, and estuarine shells. Bones and teeth of terrestrial reptiles, and of river fishes, with stems and fragments of coniferous wood, were also drifted into the estuaries and bays by the streams and rivers.† The gradual subsidence of the sea-bottom covered by these freshwater beds continued, and the sediments acquired an exclusively fluviatile character, till at length the accumulated deposits of a vast river formed an extensive delta, many hundred feet in thickness, upon the inferior strata. The imbedded organic remains attest, that throughout this epoch the fauna and flora of the country through which the river flowed, corresponded with those of the islands and continents of the oolitic period.‡

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* *Evidence:* the Fossil Forest of Portland, &c. p. 287.

† *Evidence:* the Purbeck strata, p. 255.

‡ *Evidence:* the Wealden strata and fossils, p. 240.

III. THE CRETACEOUS EPOCH.—The commencement of this era was marked by the subsidence of the entire area now occupied by the greensand formation, to a depth sufficient to admit of the accumulation of the deep sea deposits, of which the greater part of the cretaceous beds of England, and of the adjacent portion of the European Continent, consists. The Wealden sediments were submerged to a great depth, and upon them were deposited sands, and argillaceous mud, and calcareous detritus, teeming with marine exuviæ.* But the ocean of the chalk extended far beyond the limits of the Wealden; it buried beneath its waters a considerable portion of modern Europe, and its waves reached the New World, and covered part of the continent of North America. This ocean swarmed with numerous forms of marine organisms, belonging in a great measure to species and genera unknown in the earlier and in the later geological epochs. The interspersions of freshwater deposits containing terrestrial exuviæ, though inconsiderable, prove that although the delta of the country of the iguanodon was submerged in the abyss of the ocean, a group of islands, or a continent, inhabited by that colossal reptile and its contemporaries, and covered with pine-forests, cycadeæ, and ferns, flourished up to a late period of the cretaceous epoch.†

IV. THE TERTIARY EPOCH.—The bed of the chalk ocean was broken up, and considerable areas were elevated above the sea, and covered with vegetation, and tenanted by pachydermata and other mammalia; the dry land of Europe during this period was less extensive than at the present time.

In the basins and depressions formed by the submerged portions of the cretaceous strata, new sediments began to take place; the sea which deposited them teeming with marine animals, distinct from those of the pre-existing ocean. Local intrusions of freshwater deposits, abounding in the spoils of the land and its inhabitants, denote the existence of islands or continents, tenanted by mammalia allied to the tapir, elephant, rhinoceros, horse, deer, &c.;* and the vegetable remains, consisting of palms and dicotyledonous trees, indicate an approach to the flora of the warm regions of the south of Europe. A few reptiles, principally of the alligator and crocodilian types, and lizards of small size, appear as the representatives of the swarms of colossal oviparous quadrupeds of the previous epochs.

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* *Evidence:* Greensand strata at Atherfield, &c. See p. 163.

† *Evidence:* The Iguanodon, and freshwater turtles, pine-trees and cycadeæ of the greensand of Maidstone; the ferns of the greensand of the Isle of Wight, p. 167; the Clathraria Lyellii of the chalk-marl at Bonchurch, p. 179.

V. THE PRE-HISTORIC EPOCH.—From the most recent tertiary deposits, to those in which occur the remains of animals which seem to have always been contemporary with the human race, the transition is imperceptible. But elevatory movements, and subsidences, more or less general, appear to have continually taken place, by which the relative position of the land and sea was subjected to repeated oscillation. During this period, large pachyderms, as the mammoth, mastodon, hippopotamus, rhinoceros, &c.—several species of horse—gigantic elks and deer—and many carnivora, as the lion, tiger, bear, hyena, &c.—inhabited the European continent and islands. While this fauna prevailed, a succession of terrestrial disturbances occurred, by which the physical configuration of the land was materially changed. England and its islands were separated from the continent; and to this epoch is probably referable the formation of the lines of elevation that traverse the districts over which our observations have extended.

LASTLY.—Man took possession of the land, and such of the large mammalia as had survived the preceding geological revolutions were either exterminated by his agency, or reduced to a domesticated state. Subsequently to the occupation of these islands by the aboriginal tribes, the country has undergone no important physical mutations. The usual effects of the atmosphere, the wasting of the shores by the encroachments of the sea, the erosion of the land by streams and rivers, the silting up of valleys, and the formation of deltas, are apparently the only terrestrial changes to which England and its islands have been subjected during the historic ages.

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* *Evidence:* See p. 83, and p. 123.

COROLLARY.—From this examination of the geological phenomena of the south-east of England, we learn that at a period incalculably remote, there existed in the northern hemisphere an extensive island or continent, possessing a climate of such a temperature, that its surface was covered with arborescent ferns, palms, cycadeæ, and other coniferæ; and the ocean that watered its shores, was inhabited by turtles, and marine lizards of extinct genera. This country suffered a partial subsidence, which was effected so tranquilly, that many of the trees retained their erect position, and the cycadeous plants, and a considerable layer of the vegetable mould in which they grew, remained undisturbed. In this state an inundation of freshwater covered the country and its forests, and deposited upon the soil and around the trees a calcareous mud, which was gradually consolidated into limestone; thermal streams, holding flint in solution, percolated the mass, and silicified the submerged trees and plants.

A further subsidence took place, floods of freshwater overwhelmed the petrified forest, and heaped upon it accumulations of detritus, which streams and rivers had transported from the land. The country traversed by the rivers, like that of the submerged forest, enjoyed a tropical climate, and was clothed with palms, arborescent ferns, and cycadeæ; it was tenanted by gigantic herbivorous and carnivorous reptiles, and its waters abounded in turtles, and various kinds of fishes and mollusca. The bones of the reptiles, the teeth and scales of the fishes, the shells of the mollusca, and the stems, leaves, and seed-vessels of the trees and plants, were brought down by the streams, and imbedded in the mud of the delta, beneath which the petrified forest was now buried.

This state continued for an indefinite period—another change took place—the country of reptiles, with its inhabitants, was swept away, and the delta, and the fossil trees, with the marine strata on which they once grew, subsided to a great depth, and formed part of the bottom of a profound ocean; the waters of which teemed with countless myriads of zoophytes, shells, and fishes, of species long since extinct. Periodical intrusions of thermal streams charged with silex, gave rise to layers and veins of nodular and tabular flint, and occasioned the silicification of the organic remains subjected to their influence.

This epoch, which was of long duration, was succeeded by elevatory movements, by which the bottom of the deep was broken up, and large areas were slowly upheaved; and as the elevation continued, the deposits which had accumulated in the depths of the ocean, approached the surface, and were exposed to the action of the waves. These masses of cretaceous strata now began to suffer destruction, and the delta of the country of the iguanodon gradually emerged above the waters; and, finally, the petrified forest of the oolite rose in the midst of the sea, and became dry land. At length, some portions of the elevated strata attained an altitude of several hundred feet, and a group of islands was formed; but, in the basins or depressions beneath the waters, sediments derived from the disintegration of the sea-cliffs were deposited. Large herbivorous mammalia now inhabited such portions of the former ocean-bed as were covered with vegetation sufficient for their support; and as these animals died, their bones became enveloped in the accumulations of mud and gravel which were forming in the bays and estuaries.

This era also passed away—the elevatory movements continued—other masses of the bed of the chalk ocean, and of the Wealden strata beneath, became dry land—and, at length, those more recent deposits containing the remains of the herbivorous mammalia which were the last tenants of the country. The oak, elm, ash, and other trees of modern Europe now sprang up where the groves of palms and tree-ferns once flourished—the stag, boar, and horse ranged over the plains in which were entombed the bones of the colossal reptiles—and, finally, *Man* appeared, and took possession of the soil.

At the present time, the deposits containing the remains of the mammoth and other extinct mammalia, are the sites of towns and villages, and support busy communities of the human race; the huntsman courses, and the shepherd tends his flocks on the elevated masses of the bottom of the ancient chalk ocean—the farmer reaps his harvests upon the cultivated soil of the delta of the country of the iguanodon—and the architect obtains from beneath the petrified forest the materials with which to construct his temples and his palaces: while, from these various strata, the geologist gathers together the relics of the beings that lived and died in periods of unfathomable antiquity, and of which the very types have long since been obliterated from the face of the earth, and by these natural memorials is enabled to determine the nature and succession of those physical revolutions which preceded all history and tradition.

A LIST OF THE MOST IMPORTANT PUBLICATIONS RELATING TO THE GEOLOGY OF THE ISLE OF WIGHT, AND THE COAST OF DORSETSHIRE.

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I. "A Description of the Principal Picturesque Beauties, Antiquities, and Geological Phenomena of the Isle of Wight. By Sir Henry C. Englefield, Bart. With additional observations on the Strata of the Island, and their continuation in the adjacent parts of Dorsetshire, by Thomas Webster, Esq. Illustrated by maps, and numerous engravings from original drawings." 1 vol. folio. London, 1816; pp. 238, and fifty plates. Published at £4 4s.*

The many references and extracts in the present work from this splendid volume, sufficiently attest its value. The reader must bear in mind that the freshwater character of the "Iron sands" of Sussex, Kent, and Surrey, was unknown to Mr. Webster at the period of Sir H. Englefield's publication; and that the series of deposits now denominated the Wealden, comprises the "Iron or ferruginous sands" below the clays and Sussex marbles, under the name of Hastings sands; while the ferruginous sands between the Weald-clay and the galt, belong to the greensand group.

II. "Dr. Fitton's Memoir," to which reference has so often been made in the preceding pages, is published in vol. iv., new series, of the *Transactions of the Geological Society of London;* and may be purchased separately, as well as several of the following, at the Society's apartments, Somerset House. It is entitled—

"Observations on some of the Strata between the Chalk and the Oxford Oolite in the South-east of England;" pp. 286, five coloured maps, three large plates of sections, and fourteen plates of fossils. Price £1 10s.

III. "On the Geology of the Neighbourhood of Weymouth and the adjacent parts of the Coast of Dorset." By the Rev. Dr. Buckland (now Dean of Westminster), and Sir H. De la Beche.

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* This fine work is now sold by Mr. Bohn, who has the stock, for £1 16s.

Geological Transactions, vol. iv. new series, pp. 46; with a large coloured map, and two plates of coloured sections. Price 7s.

IV. "On the Discovery of Fossil Bones of the Iguanodon in the Wealden Formation of the Isle of Wight, and in the Isle of Purbeck. By the Rev. Dr. Buckland." *Geol. Trans.*, vol. iii, pp. 8. One plate. Price 3s. 6d.

V. "Inquiries respecting the Geological Relations of the Beds between the Chalk and the Purbeck Limestone in the South-east of England. By Dr. Fitton." *Annals of Philosophy* for November, 1824.

VI. "On the Purbeck and Portland Beds. By Thomas Webster, Esq., Secretary of the Geological Society." *Geol. Trans.*, vol. ii. second series, pp. 4, One plate of fossils. Price 2s. 6d.

VII. "On the Cycadeoideæ, a Family of Fossil Plants found in the Quarries of the Isle of Portland. By the Rev. W. Buckland, D.D., &c." *Geol. Trans.*, vol. ii. second series; pp. 8, with four plates. Price 5s.

VIII. "Outlines of the Geology of England and Wales. By the Rev. W. D. Conybeare, and W. Phillips, Esq." 1 vol. 8vo. London, 1822. This admirable work contains a compendium of the geological phenomena of the Isle of Wight and the adjacent coasts, so far as known at the period of its publication.

IX. "Observations on Part of the Sections of the Lower Greensand at Atherfield, on the Coast of the Isle of Wight. By W. H. Fitton, M.D., &c." *Proceedings of the Geological Society*, vol. iv. p. 198.

X. "On the Thickness of the Lower Greensand Beds of the South-east of the Isle of Wight. By F. W. Simms, Esq." *Quarterly Journal of the Geological Society*, vol. i. p. 76.

XI. "Comparative Remarks on the Sections below the Chalk on the Coast near Hythe in Kent, and Atherfield in the Isle of Wight. By Dr. Fitton." *Quarterly Journal of the Geological Society*, vol. i. p. 179.

XII. "On the Section between Blackgang Chine and Atherfield Point. By Capt. L. L. B. Ibbetson and Professor Edward Forbes." *Quarterly Journal of the Geological Society*, vol. i. p. 190.

XIII. "Catalogue of Lower Greensand Fossils in the Museum of the Geological Society. By Professor Edward Forbes, F.R.S., &c." *Quarterly Journal of the Geological Society*, vol. i. p. 237, and p. 345.

THE FOLLOWING MEMOIRS PRINCIPALLY RELATE TO THE STRATA ABOVE THE CHALK.

I. "On the Freshwater Formations in the Isle of Wight, with some observations on the Strata over the Chalk in the South-east Part of England. By Thomas Webster, Esq." *Geol. Trans.*, vol. ii. (published in 1814.)

II. "On the Freshwater Formation in Hordwell Cliff, Hampshire, and on the subjacent Beds from Hordwell to Muddiford. By Thomas Webster, Esq." *Geol. Trans.*, vol. i. p. 90, second series.

III. IV. "On the Strata of the Plastic Clay Formation exhibited in the Cliffs between Christchurch Head in Hampshire and Studland Bay in Dorsetshire." And "On the Freshwater Strata of Hordwell Cliff, Beacon Cliff, and Barton Cliff, Hampshire. By Charles Lyell, Esq., F.R.S., &c." *Geological Transactions*, vol. ii. second series; pp. 14, with a coloured map. Price 7s.

V. "On the London and Plastic Clay Formations of the Isle of Wight. By J. S. Bowerbank, Esq., F.R.S." *Geological Transactions*, vol. vi. pp. 4. Woodcuts. Price 1s. 6d.

VI. "Remarks on the Existence of Anoplotherium and Palæotherium in the Freshwater Strata at Binstead, near Ryde, in the Isle of Wight. By Samuel Peace Pratt, Esq., F.R.S." *Geological Transactions*, vol. iii. pp. 3. Price 3s.

VII. "Description of some Fossil Remains of Chæropotamus, Palæotherium, Anoplotherium, and Dichobune, from the Eocene Formation, Isle of Wight. By Professor Owen." *Geological Transactions*, vol. vi. pp. 19; two plates. Price 7s.

VIII. "On the Tertiary or Supra-cretaceous Formations of the Isle of Wight, as exhibited in the Sections at Alum and Whitecliff Bays. By Joseph Prestwich, jun., Esq." *Quarterly Journal of the Geological Society*, vol. ii. pp. 224-259.

IX. "On the Discovery of the Fossil Remains of an Alligator and of several previously unknown Mammalia in the Hordwell Cliff; with Observations upon the Geological Phenomena of that Locality. By Mr. Searles Wood, F.G.S." In *The London Geological Journal and Record of Discoveries in British and Foreign Palæontology*, p. 1. September, 1846. Published every second month by Churchill, London.

⁂ Models of the Isle of Wight, coloured geologically (price from 5s. to £2 2s.), may be obtained of Mr. R. T. Wilde, 19, Cursitor Street, Chancery Lane. The purchaser should order the model to be coloured in accordance with the geological map of this volume.

MEMOIRS PUBLISHED SINCE THE FORMER EDITION.

I. "On the Probable Age of the London Clay, and its Relations to the Hampshire and Paris Tertiary Systems. By Joseph Prestwich, jun., Esq., F.G.S." *Geological Journal,* vol. iii. pp. 354—379.

II. "On the main points of Structure and the Probable Age of the Bagshot Sands, and their presumed Equivalents in Hampshire and France. By the same." *Geological Journal,* vol. iii. pp. 378-409.

The above admirable memoirs by Mr. Prestwich are very elaborate, and illustrated by sections. They should be consulted by all who are desirous of understanding the characters and relations of the tertiary formations of England and France.

III. "A Stratigraphical Account of the Section from Atherfield to Rocken End, on the South-west Coast of the Isle of Wight. By William Henry Fitton, M.D., F.R.S., &c." *Geological Journal,* vol. iii. pp. 289-327.

This is a most important memoir, containing the fullest information on the stratification and fossil remains of the entire series of deposits constituting the greensand formation of the south-east of England. It gives in detail the subdivisions of the strata, and a complete view of the distribution of the fossils in the respective beds. It is accompanied by two elaborate tables. The first is entitled, "Comparative Sections of the Lower Greensand in England and France;" the other, "A Stratigraphical Section from Atherfield Point to Black-Gang Chine." The characters of the lowermost group of the greensand, the "*Terrain Néocomien*" of the French geologists, as developed in the Isle of Wight, are accurately determined, and illustrated by sections and sketches. Every instructive headland or chasm, or chine, along the coast, is sketched and described. The visitor to Ventnor or Black-gang who has leisure to examine this most interesting line of coast, will find this memoir an invaluable handbook.

IV. "On the Geology of Ridgway, near Weymouth. By C. H. Weston, Esq." *Geological Journal,* vol. v. p. 245 and p. 317.

In a section exposed by the railway cutting through Ridgway Hill, the author discovered the Wealden, Purbeck, and Portland deposits, with characteristic fossils.

V. "On the occurrence of Productive Iron Ore in the Eocene Strata of Hampshire. By Alfred Taylor, Esq., F.G.S." *Geological Journal,* vol. vi. p. 133.

VI. "On the Position and General Characters of the Strata exhibited in the Coast Section from Christchurch Harbour to Poole Harbour. By Joseph Prestwich, jun., Esq." *Geological Journal*, vol. v. p. 43.

VII. "On the occurrence of Eocene Freshwater Shells at Beaulieu, Langley, &c., in Hampshire. By J. C. Moore, Esq., Secretary of the Geological Society." *Geological Journal*, vol. v. p. 315.

VIII. "On the Structure of the Strata between the London Clay and the Chalk in the London and Hampshire Tertiary Systems. By Joseph Prestwich, jun., Esq." *Geological Journal*, vol. vi. p. 252.

IX. "A Description of a New Species of Nautilus (*N. Saxbii*) from Atherfield. By John Morris, Esq., F.G.S." *Geological Journal*, vol. v. p. 193.

X. "On the Fossil Remains of Mammalia referable to the Genus Palæotherium, and to two Genera, Paloplotherium and Dichodon, hitherto undefined, from the Eocene Sand of Hordwell. By Professor Owen." *Geological Journal*, vol. v. p. 17.

XI. "Description of Teeth and Portions of Jaws of two extinct Quadrupeds, *Hyopotamus vectianus*, and *H. bovinus*, discovered by the Marchioness of Hastings in the Eocene Deposits on the North-west Coast of the Isle of Wight. By Professor Owen." *Geological Journal*, vol. v. p. 103.

XII. "On Fossil Zoophytes from Atherfield. By W. Lonsdale, Esq., F.G.S." *Geological Journal*, vol. v. p. 55.

XIII. "Observations on the Osteology of the Iguanodon and Hylæosaurus. By G. A. Mantell, LL.D., &c., and A. G. Melville, M.D., &c." *Philosophical Transactions*, 1849.

In this memoir the humerus of the Iguanodon, and several vertebræ from the Isle of Wight, are figured and described.

XIV. "Notice of the Organic Remains recently discovered in the Wealden Formation. By G. A. Mantell, LL.D., &c." In the *Quarterly Journal of the Geological Society* for February, 1849.

This paper contains a summary of the recent additions made to the fauna and flora of the Wealden; especially those from the Isle of Wight.

XV. "Monograph on British Fossil Reptiles. By Professors Bell and Owen." Published by the Palæontographical Society. Parts I. and II. 1849, 1850.

SUPPLEMENTARY CHAPTER.

ADDITIONAL OBSERVATIONS ON THE GEOLOGY OF THE ISLES OF WIGHT AND PURBECK, WITH NOTICES OF THE MOST REMARKABLE FOSSILS RECENTLY DISCOVERED.

INTRODUCTORY—CLASSIFICATION OF THE EOCENE STRATA—SECTION AT RYDE—FOSSIL MAMMOTH—TERTIARY FOSSILS—DICOTYLEDONOUS LEAVES—PALM-LEAF FROM WHITECLIFF BAY—EOCENE TURTLES—CROCODILES—SERPENTS—MAMMALIA—CRETACEOUS FORMATION—BELEMNITELLA—PTEROCERA FROM ATHERFIELD—ANCYLOCERAS—MOLLUSKITE AND PHOSPHATIC STRATA—WEALDEN FORMATION—FIR-CONES—ABIETITES DUNKERI—WEALDEN REPTILES—PURBECK STRATA—RETROSPECTIVE SUMMARY.

SEVERAL valuable communications relating to the geology and fossil remains of the district this volume is designed to illustrate have been published since the former edition in the "Quarterly Journal of the Geological Society of London;" a list of these memoirs is prefixed.

The most important are those on the "Greensand Formation, as exposed in the range of cliffs that extends along the southern coast from Sandown Bay to Compton Bay, by Dr. Fitton"; on the "Classification of the Tertiary Deposits, by Mr. Prestwich"; and on the "Fossil Remains of some new species and genera of Mammalia from the eocene strata of the Island, by Professor Owen." In the monographs on British fossils now in course of publication by the Palæontographical Society, there are likewise figures and descriptions of the remains of several species and genera of fossil turtles, crocodiles, and serpents, and of shells, from the tertiary strata of Hampshire and the Isle of Wight. In my recent communications to the Royal Society on the iguanodon, hylæosaurus, and other saurians from the Wealden, many of the illustrations are from fossils obtained from Sandown and Brixton bays.

In the following account of these and other additions to the geology and palæontology of the island, the most interesting facts and observations are coneisely noticed.

§ 1. CLASSIFICATION OF THE TERTIARY STRATA.—A review of the fossil remains and stratigraphical characters of the deposits comprised under the general term "London Clay," (see the tabular arrangement, p. 43,) has led Mr. Prestwich to modify his former classification of the eocene strata of England. The lowermost beds at Alum Bay, the mottled clays, &c., Mr. Prestwich now conceives are naturally separated from the London clay, strictly so called, by a basement line, which he thus describes: "In the fine section at Alum Bay there may be seen, at a distance of about ninety-four feet from the chalk, a layer, not a foot thick, of rather large rounded black flint-pebbles, imbedded in green or furruginous yellow sand and brown clay, which separates the mass of the London clay on the one side from that of the mottled clays on the other, and constitutes the base of the former. This pebble-band contains a few organic remains, of which the most common are the teeth of a species of *Lamna* (Shark), and the *Ditrupa plana* (see Pl. III. fig. 3): it lies upon a somewhat uneven and worn surface of the underlying stratum. Inconsiderable in thickness, this bed is, nevertheless, remarkable for the extent of its range, the uniformity of its lithological characters, and the permanence of its organic remains—conditions of the more value from the position of this stratum between the two main members of the eocene series. It forms an excellent base-line, and its characters are so well marked, that it can be traced without much difficulty from the Isle of Wight to Woodbridge in Suffolk, a distance in a straight line of above 160 miles from south-west to north-east. It constitutes a distinct horizon, separating the London clay formation, by a change both in the palæontological conditions and in the ancient physical geography of the district, from the older eocene deposits which intervene between it and the chalk; its mineral mass being composed of the debris of the latter, while its animal remains belong to the period of the former."

At Whitecliff Bay, (p. 91) this "basement-bed" consists of a layer of brown sandy clay, with tabular septaria, mixed with greensand, and passes down into a conglomerate of flint pebbles and rounded fragments of chalk, with masses of greensand, full of the shells of *Ditrupa plana.*[*]

The basement bed contains altogether, in the various known localities, thirty species of testacea,[†] of which eight or ten are probably undescribed. *Panopæa intermedia, Rostellaria Sowerbyi, Cardium Plumsteadiense,* and *Calyptrea trochiformis,* are persistent throughout. The Hampshire tertiary series is now arranged by Mr. Prestwich in the following order: 1. (lowermost) Mottled clays and sands; 2. London clay, including the basement bed and Bognor strata; 3. Bracklesham (and Bagshot) deposits; 4. Barton clays; 5. Fluvio-marine, and Freshwater series.[‡]

The following table shows the equivalents in the London and Paris districts :—

LONDON.		ISLE OF WIGHT.	PARIS.	
		Freshwater and Estuary series	Upper	Calcaire Grossier.
		Barton Clay	Lower	
Bagshot.	Upper Middle Lower	Bracklesham series	Glaucoine grossière, Sables et Grès.	
London Clay		London Clay (*Bognor beds*)	Lits Coquilliers.	
Mottled Clay, and lower sands.		Mottled Clays, and lower sands.	Argile plastique et sables inférieurs.	

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[*] For details, see "Quart. Geol. Journal," vol. vi. pp. 256, 274.

[†] Ibid. p. 278.

[‡] "Quart. Geological Journal," vol. iii., p. 400.

According to this arrangement, the bed of oysters (chiefly of one species, *Ostrea bellovacina,*) which occurs at Reading, at Headley in Surrey, and at Newhaven in Sussex, is below the basement-bed of the London clay. The Bromley oyster-bed, Mr. Prestwich thinks, may probably be on the same level. At Castle Hill, near Newhaven, the oyster-bed is immediately covered by the pebble-bed, and masses occur of a hard conglomerate, composed of oyster-shells and pebbles, like that of Bromley.*

§ 2. SECTION OF THE FRESHWATER STRATA NEAR RYDE.—In 1847, Mr. Dashwood, the intelligent proprietor of the water-works in the valley at Dover, near Ryde, bored to the depth of about 140 feet in quest of water; the following strata were passed through:—1. Shore shingle and sand, 13 feet; 2. Blue clay, 5 feet; 3. Freshwater limestone, the bottom layer, blue rag, 14 feet; 4. Whitish loam, 3 feet; 5. Blue clay, with shells, 4 feet; 6. Indurated blue clay, 9 feet; 7. White sand, 5 feet; 8. Blue clay, with few shells, 16 feet; 9. Layer of soft sandstone, 1 foot; 10. Greenish and blue clay, with intermixture of sand, full of freshwater shells, like those at Headon Hill, 64 feet. No organic remains of interest were obtained.

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* The interesting outlier of eocene strata at Castle Hill, of which a sketch of the natural section, exposed in 1822, forms the frontispiece of my "Fossils of the South Downs," is rapidly wasting away, from the inroads of the sea on the chalk cliffs below. On a visit to the spot, after an interval of ten years, I found all the well-known sections were destroyed, and inconsiderable vertical breaks here and there, from recent slips, were the only spots in which the relative positions of any of the beds could be examined. The whole face of the hill towards the sea was in so fissured a state as to render much caution necessary in traversing it.

§ 3. REMAINS OF ELEPHAS PRIMIGENIUS IN THE DRIFT. The only additions to the mammalian relics from the diluvial loam and gravel previously recorded, namely, of the horse, deer, ox, and reindeer, are the remains of teeth and tusks of the mammoth, or extinct elephant, found near Ryde, by Dr. Bell Salter.

§ 4. FOSSILS FROM THE TERTIARY STRATA.—Many new species and genera of shells, and a few small corals, have been obtained from the eocene deposits of the island and the neighbouring coast of Hampshire; but without extended descriptions and numerous figures, incompatible with the plan of this work, it would be useless to particularise them. Fortunately the British corals and shells are in the course of publication by able naturalists, in the monographs of the Palæontographical Society; and a still more desirable source of instruction is now within reach of the collector, namely a series of specimens of all the genera and most of the species of the Hants and Isle of Wight tertiary shells, labelled and arranged, and at very moderate prices, by the British Natural History Society, established and conducted by Edward Charlesworth, Esq., of the Scientific Institution of York.

The most interesting vegetable and reptilian and mammalian remains discovered since the former edition are noticed in the following pages.

§ 5. FOLIAGE OF DICOTYLEDONOUS TREES.—In a previous chapter, (*ante*, p. 122,) a short account is given of the occurrence of dicotyledonous leaves belonging to a few genera, in some thin layers of sandy clay in the cliffs a short distance west of Bournemouth, in Hampshire; but, inadvertently, no reference was made to the previous notice of this fact by the Rev. P. B. Brodie, in the Proceedings of the Geological Society.*

I have lately obtained some beautiful specimens col-

* Vol. iii. p. 592.

lected from the same locality by Miss Kell, of Lewes. All the leaves I have examined are dicotyledonous, and appear to have been shed; many are referable to the Lauraceæ and Amentaceæ. Some of them resemble species of willow, poplar, laburnum, &c.; but it is impossible from a detached leaf to arrive at any definite approximation to the species or even genus.* When the sandstone is first broken, the leaves are generally very perfect, and present a glossy surface; but the epidermis soon shrivels and falls off, leaving only the ribs and nervures, or their impressions; a coating of thin gum-water immediately after the leaves are exposed will preserve them.

In Alum Bay, above the "basement bed" of the London clay, there is a thin stratum of light-coloured laminated clay, which abounds in similar vegetable remains. Mr. S. Pearce Pratt and Mr. Prestwich have made considerable collections from this place: this deposit is supposed to be 300 or 400 feet lower in the series than the analogous layers at Bournemouth.†

§ 6. FOSSIL PALM-LEAF, FROM WHITECLIFF BAY.—To the discrimination and assiduity of Mr. Fowlstone I am indebted for the preservation of this highly interesting addition to the fossil flora of the Isle of Wight.

It is a flabelliform, or fan-like leaf of a palm, and was found imbedded in a large mass of fawn-coloured limestone that had fallen from the freshwater strata of the cliffs, and been lying within reach of the waves sufficiently long for the surface to be partially covered with fuci and algæ. On splitting off a portion of the rock, the leaf was exposed in the state delineated in the annexed engraving (lign. 37); the piece removed bears the corresponding imprint, and has on its external surface numerous fragments of the carbonised foliage of palms, and vestiges of a club-moss (*Lycopodium*), and other plants resembling certain species described by M. Brongniart as occurring with similar palm-leaves in the eocene strata of France. This frond belongs to the species of fossil palm figured and described by M. Adolphe Brongniart as *Palmacites Lamanonis*,[†]

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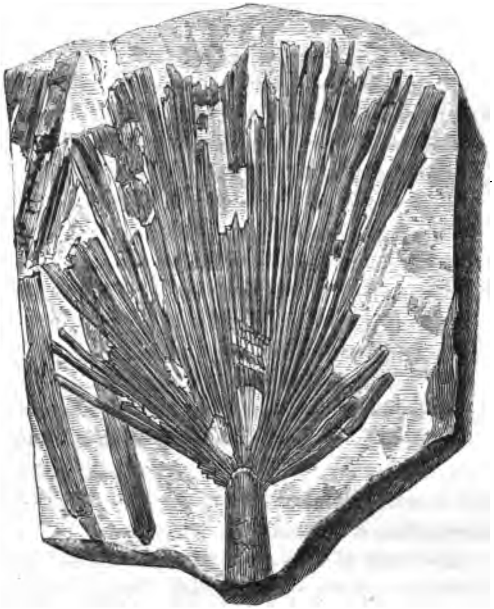
* In Tab. xxiii. of MM. Dunker and Von Meyer, "Palæontographica," several leaves are figured from the molasse of Günzburg, which appear identical with some of those from Bournemouth.

† The reddish marl containing dicotyledonous leaves, at Castle Hill, Newhaven, is a thin layer, which lies *below* the basement-bed. See "Fossils of the South Downs," Pl. I.



LIGN. 37—FOSSIL PALM-LEAF FROM WHITECLIFF BAY.—¼ Nat. size.
(*Palmacites Lamanonis.*)[*]

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[*] Mémoires du Mus. d'Hist. Nat. tom. viii. pt. iii. fig. 1.

[†] The specific name is derived from M. Lamanon, who first discovered this palm at Aix.

from specimens obtained at Aix, in Provence; a locality rich in eocene fossils, and whence, by the kindness of my friends, Sir C. Lyell and Sir R. Murchison, I procured, in 1829, a beautiful example of this kind, and a large collection of fishes, insects, shells, &c., now in the British Museum.*

The Isle of Wight palm-leaf is thirteen inches in length, and eleven inches in width; it retains two inches of the petiole or leaf stalk, which is smooth and without spines, and somewhat prolonged at the extremity in which the leaf is inserted. The leaf is plicated in small folds at the base, and expands in diverging lobes, which separate towards the summit; these are half-an-inch wide, and on some of them fine linear elevated striæ or nervures may be distinctly traced. The general aspect of the fossil is that of a fan half opened. The vegetable tissue that remains is in the state of a dark brown carbonaceous substance, forming a thin pellicle of lignite. Gyrogonites (see p. 78, lign. 5,) and several freshwater shells (paludina, limneus, planorbis, see pl. 1,) are imbedded in the stone; and numerous casts of cyprides (minute fluviatile crustaceans, see p. 223) are distributed among the carbonised foliage on the outer surface of the mass.

The discovery of this specimen proves that by diligent and judicious research at Whitecliff Bay, many important additions might be made to the flora of the country which was inhabited by the extinct races of pachydermata, whose bones and teeth are imbedded in the tertiary strata of this island and of the continent.

§ 7. EOCENE REPTILES.—CHELONIA, OR TURTLES.—A few detached ribs, scutes, and bones of two or more species of emys and trionyx, from Binstead and Headon Hill, are the only vestiges of chelonian reptiles I have collected since my former notice of the eocene chelonians of the island (*ante*, p. 80): but several splendid examples of freshwater turtles, having the carapace almost perfect, have been discovered by the Marchioness of Hastings, and are now preserved in her ladyship's choice museum.* Seven species are figured and described in the "Monograph on the Fossil Reptiles of the London Clay,"† a work to which the collector should refer to ascertain the characters and relations of any specimens of this kind he may be so fortunate as to obtain.

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* See the "Memoir on the Freshwater Formation at Aix, in Provence," by Messrs. Lyell and Murchison, "Jameson's Edinburgh Journal," 1829. Figures of some of the fishes and insects are given in my "Wonders of Geology," 6th edit., vol. i. p. 261.

§ 8. CROCODILIAN REPTILES.—In addition to the jaw, teeth, and other parts of the skeleton of the alligator (*A. Hantoniensis*, p. 125), and of a species of crocodile (*C. Spenceri*, p. 118), the eocene deposits of Hordwell and Lymington have yielded to the researches of the Marchioness of Hastings, and of Messrs. Falconer, other remains of crocodiles.

The most remarkable of these interesting relics is the cranium and lower jaw with teeth in a very perfect state, and vertebræ, of a species named, in honour of its noble discoverer, *C. Hastingsiæ*;‡ the skull is eighteen inches long. In their general characters the jaws bear a close analogy to those of the alligator described by Mr. Searles Wood, but are distinguished by the groove or notch in the upper maxilla, for the reception of the fourth canine tooth of the lower jaw, which, in the alligator, is received in a circumscribed cavity.

FIRST CAUDAL CROCODILIAN VERTEBRA.—I cannot pass by without comment the remarkable fact, that the first caudal vertebra of each of the three Hordwell species of crocodiles has been obtained. In 1837, the discovery of the very fine specimen of crocodilian reptile at Swanage, now in the British Museum, induced me to institute a rigorous examination of the skeleton of a large gavial in Dr. Grant's collection, with the view of determining the characters and relations of the fossil reptile. I then ascertained that the body or centrum of the first caudal vertebra in the adult gavial is convex at both ends; this remarkable modification being necessary in consequence of the concavity of the anterior and posterior articulations of the two anchylosed vertebræ that form the sacrum: as this character was not mentioned by Cuvier, nor by any other author to which I had access, a description, with figures, was published in "The Lancet," and in my "Wonders of Geology" (vol i., p. 418). The importance of this knowledge to the palæontologist was quickly shown by the occurrence of a doubly convex vertebra in some Himalayan fossils received from Major Cautley by Dr. Buckland, and which had occasioned many vague surmises. It is peculiarly gratifying to me to find that the value of this discovery is strikingly exemplified in the present instance, as the following observations of Professor Owen testify: "The first caudal vertebra which presents a ball for articulating with a cup on the back part of the last sacral, retains, nevertheless, the typical position of the ball on the back part of the centrum; it is thus biconvex, and the only vertebra of the series which presents that structure. I have had this vertebra in three different species of extinct eocene crocodilia. The advantage of possessing such definite characters for a particular vertebra is, that the homologous vertebra may be compared in different species, and may yield such distinctive characters as will hereafter be pointed out in those of the three species above cited."*

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* At Efford House, near Lymington.

† Published by the Palæontographical Society of London.

‡ Figured and described by Professor Owen in the same Monograph.

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* "Foss. Rept. of the London Clay," p. 15.

§ 9. Fossil Serpents.—Vertebræ of large serpents have of late years been found not unfrequently in the London clay at Sheppey and Bracklesham. In the Memoir above cited,* a summary of the osteological characters of the vertebral column of the ophidians forms the introduction to the figures and descriptions of several species and genera of serpents of colossal size which existed during the eocene period. I believe no ophidian vertebræ have hitherto been collected in the Isle of Wight; but from Hordwell, Mr. Searles Wood and Mr. Falconer have obtained several belonging to two species of land-serpents, the one between two and three feet, and the other four feet long. In the eocene clay of Bracklesham many vertebræ of a sea-serpent, at least twenty feet in length, have been discovered.†

§ 10. Eocene Mammalia.—A few remains of palæotheria have been obtained from the compact limestone near Ryde. In a block, lying on the sea-shore, a fine lower jaw with teeth of *Palæotherium magnum* was discovered by a man employed in breaking stones, during my visit in 1848, but the specimen was so fragile from long immersion in the sea, that fragments of the crowns of the teeth only were preserved. Of a species of anoplotherium several teeth and a portion of the jaws were collected in the quarry at Binstead.

The most important additions to the fossil mammalia of the island are the jaws and teeth of a remarkable genus of pachyderms, allied to anthracotherium, from the freshwater strata of Headon Hill, by the Marchioness of Hastings, and described by Professor Owen under the name of *Hyopotamus*;‡ and from Hordwell, of the entire cranium and jaws with teeth of a species of palæotherium, and of two allied genera, *Paloplotherium*, and *Dichodon*.*

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* "Foss. Rept. of the London Clay," p. 50.

† Ibid. p. 61.

‡ Two species have been defined: *H. bovinus*, and *H. vectianus*.—"Quart. Geol. Journal," vol. iv. p. 103.

From the same inexhaustible mine of eocene treasures, Hordwell Cliff, teeth of the *Hyænodon*, a most remarkable extinct genus of the dog tribe, have been obtained; this extraordinary carnivorous animal is characterised by the modification of the dental organs, the arrangement and characters of the teeth being altogether peculiar; the last molar in the lower jaw closely resembles a sectorial (scissor-like) tooth of the hyena, whence the name of the genus.†

§ 11. CRETACEOUS FORMATION (*ante*, p. 127).—From this extensive series of deposits a great many beautiful examples of the previously known cretaceous fossils, and a few new species and genera of shells have been brought to light by the authors of the memoirs enumerated in the list of new publications, (*ante*, p. 303,) and by Mr. Saxby, Mr. Beckles, and other collectors. A reference to the papers in the "Quarterly Geological Journal," and an examination of the figures accompanying them, will show what important acquisitions have been obtained during the last three years, especially from the greensand deposits at Atherfield, and mainly by the researches of Dr. Fitton.

§ 12. PHRAGMOCONE OF BELEMNITELLA, FROM VENTNOR.—Among the interesting fossils collected by Mr. Beckles are three or four specimens, which I have selected for illustration; one of them is a cast in flint of the alveolus, or cavity of the rostrum or guard, of a species of *belemnitella*, from the chalk downs near Ventnor. It not unfrequently happens when belemnites‡ are imbedded in flint, that the spathose radiated guard of the osselet, not having been permeated by silex, has decomposed, and left a cavity in the stone, into which projects an elongated conical body, which is a silicious cast of the phragmocone, or chambered internal shell. Such is the case in the present instance, which is an interesting specimen, because it distinctly exhibits the upper termination of the phragmocone in belemnitella (fig. 1, *a*), the arrangement of the transverse septa, and a cast of the longitudinal band on the ventral aspect. (Fig. 2.) The genus belemnitella differs from belemnites, in having a longitudinal slit or fissure in the guard through the extent of the alveolus, or cavity in

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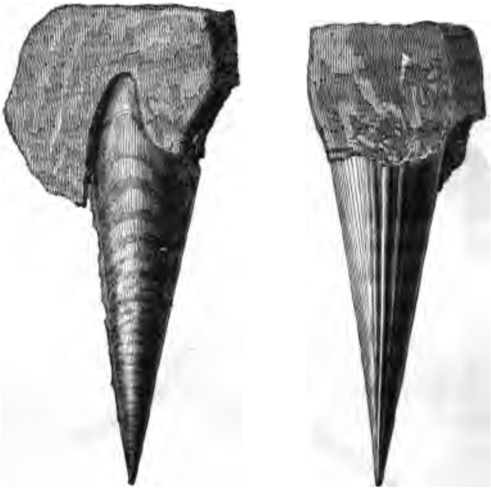
* "Geol. Journal," vol. iv. p. 17.

† Two species of hyænodon occur in the eocene strata of France.

‡ The fossil called belemnites (*vulgo*, thunderbolt), is the rostrum, or solid distal termination of the osselet, or internal skeleton of an extinct type of cephalopodous mollusca, allied to the sepiadæ, or cuttle-fish tribe.

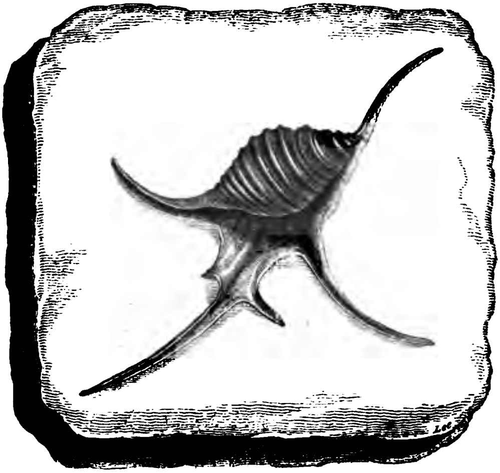


LIGN. 38.—PHRAGMOCONE OF BELEMNITELLA, IN FLINT.—Nat. size.
(*In the cabinet of S. H. Beckles, Esq.*)

Fig. 1.—Lateral aspect, showing the upper margin or peristome, and the transverse lines produced by the septa.
2.—Ventral aspect, displaying the longitudinal ridge.

which the phragmocone is situated, and other important characters.*

§ 13. PTEROCERA,† FROM ATHERFIELD.—Several beautiful species of this genus of marine univalve shells occur in the lower greensand or neocomian strata at Atherfield, two of which are represented in the following lignographs from specimens collected by S. H. Beckles, Esq. The first is a well-known species in the equivalent strata of France, and has been named *Pterocera Moreausiana* by M. D'Orbigny.



LIGN. 39—PTEROCERA MOREAUSIANA, FROM ATHERFIELD.—Nat. size.
(*In the cabinet of S. H. Beckles, Esq.*)

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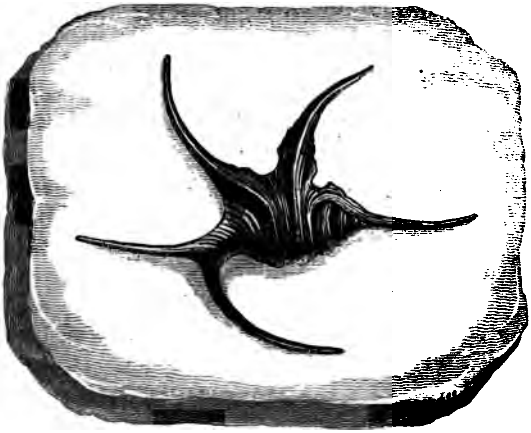
* The reader should consult the article *Belemnites* in the Supplementary Notes, p. 169, of my "Pictorial Atlas of Organic Remains." 1 vol. 4to. 75 plates. 1850. Henry G. Bohn.

† *Aporrhais*, the original name given to this genus by Aldrovandus, is employed by some naturalists, but to avoid confusion it is desirable to retain that generally adopted by the French and English Palæontologists.

The body of this shell is of an oval form, the spire consisting of five whorls, which are finely striated and ribbed spirally;* the lip expands into four long curved digitations, the peculiar form of which, and of the aperture of the shell, are well shown in the specimen. (Lign. 39.†) There are three species of pterocera in the lower greensand, which bear considerable resemblance to each other, namely, *Pterocera Fittoni*, ("Geol. Trans.," vol. ii., Pl. II., fig. 6,) *P. Retusa*, ("Geol. Trans.," 2nd series, vol. iv., Pl. XVIII., fig. 22.) and *P. Moreausiana*, described and figured by M. D'Orbigny.



LIGN. 40—PTEROCERA BECKLESII, FROM ATHERFIELD.
(*Nov. spec. in the cabinet of S. H. Beckles, Esq.*)

§ 14. PTEROCERA BECKLESII.—The other species, lign. 40, in the general aspect of the body and spire, resembles *P. Fittoni*, but the strong carinated ribs of the body-whorl are crenated in the latter, and smooth and sharply-keeled in this shell, which is, moreover, remarkably distinguished from all the allied forms, by the division of the inferior digitation into two distinct processes; one of these is prolonged downwards in a direction nearly continuous with the channel, and the other is recurved upwards. As eight or nine similar specimens have been found, the bifurcation of the inferior digitation is, in all probability, a specific character; if this should prove to be the case, I propose to distinguish the species by the name of the assiduous and accurate observer by whom it was first discovered. The figure shows the dorsal aspect of the shell.

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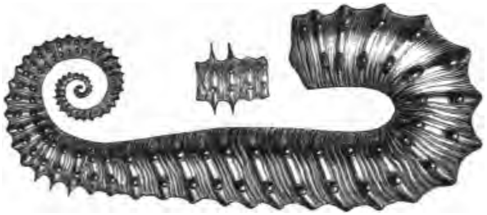
* I much regret that these characters are not accurately expressed by the artist in the figure.

† In *Rostellaria* the upper digitation is not in contact with the spire.

§ 15. ANCYLOCERAS, FROM ATHERFIELD.—Among the treasures obtained from the same locality by Mr. Beckles, is a spendid example of one of the most elegant shells of the elongated type of cephalopoda that occurs in the cretaceous formation; it is a species of *ancyloceras*, a genus related to scaphites, but characterised by the turns of the spire or coil being distant from each other, while in the latter they are in close contact, and by other well-marked peculiarities. Fine specimens of *Scaphites gigas* (Pl. V., fig. 11,) have for some years been occasionally obtained from Atherfield, but this beautiful allied form was previously



LIGN. 41—ANCYLOCERAS MATHERONIANUS D'ORBIGNY.†—¼th Nat. size.
From the Cracker-rocks, Atherfield.
(*In the cabinet of S. H. Beckles, Esq.*)

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[*] Paléontologie Française; terrains crétacés, Pl. CXXII.

unknown in the British strata. Several examples have been discovered in France, and the species is figured and described by M. D'Orbigny, with the above specific name, in honour of M. Matheron, who first collected this shell at Cassis, Bouches-du-Rhône.

This fossil is about nine and a half inches long, and of an oblong form; its spire is composed of two or three distinct coils, which occupy about one-fourth the entire length of the shell; it is traversed obliquely by prominent ribs, each bearing six tubercles, which are the bases of spines;* between each tuberculated rib there are three or four small smooth intermediate ones. The aperture of the shell is oval; the rows of turbercles form three distinct series on each side; the back or keel is rounded, with a row of tubercles on each margin, as shown in the upper figure, which represents a portion near the spire. The specimen is a very sharp cast, which in some parts is covered by the remains of the shell.

§ 16. PHOSPHATIC CRETACEOUS BEDS,† *Molluskite.*—The occurrence of the mineralised remains of the soft bodies of the mollusca whose shells occur in the firestone and greensand strata, either in amorphous masses, or as casts filling up the cavities of shells, is noticed in p. 181, and reference made to a more detailed account in the "Medals of Creation." The layers of firestone, or upper greensand, forming a junction with the galt, abound in these fossils; and this fact was pointed out in 1822, in my "Fossils of the South Downs;" in Hants, Kent, and Surrey, the lowermost bed of galt, in contact with the greensand below, is equally rich in similar remains. These beds of molluskite are very persistent, and may be traced through Sussex, Surrey, Kent, and Hampshire, and in the Isle of Wight along the Undercliff. The same fossils also occur abundantly in some of the strata or chalk marl above, and of the greensand below the galt.

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* Such also is the case in *Turrilites tuberculatus;* that the tubercles on the casts are merely the bases of spines, may be seen in specimens in my cabinet.

† The name given by Capt. Ibbetson, Mr. Nesbitt, and others, to the strata abounding in molluskite and phosphate of lime.

Molluskite has lately been in much request for agricultural purposes, the large quantity of phosphate of lime it contains rendering it a valuable manure for certain soils. A Memoir "On the Position in the Cretaceous Series of Beds containing Phosphate of Lime" has been published;* and Mr. Nesbitt has analysed hundreds of specimens to show the proportionate quantity of phosphate of lime in particular nodules and beds. The first notice of these substances in the upper greensand strata at Farnham was announced as the discovery of a bed of fossil guano, and great expectations were raised that it would prove an inexhaustible mine of wealth.

At the present time (1851) many persons are engaged on the summit of the hill above Blackgang in extracting the casts of ammonites and other shells, and the nodular masses of molluskite, from the arenaceous green marl that crops out from beneath the upper chalk along the heights of the escarpment of the Undercliff; the loose rubble, it is said, is rejected, probably because analysis has shown that the casts of ammonites, &c., contain the largest proportion of phosphate of lime; for in Mr. Nesbitt's tables of phosphoric acid in nodules and casts of shells from St. Catherine's Downs, the casts are stated to contain from 40 to 50 per cent. of phosphate of lime, while the surrounding greensand, or hassock, yields but from 2 to 10 per cent. Probably the combination of the calcareous earth, filling the shell, with the phosphoric acid derived from the soft parts of the mollusks has imparted this excess to the casts. The Government Geological Survey of the Island, which is now in progress, will doubtless give detailed information respecting the extent, position, and chemical constituents of these deposits.*

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* "Geological Journal," vol. iv. p. 257.

It is worthy of remark, that the presence of phosphoric acid is not confined to deposits teeming with the remains of animal structures: traces of it occur even in volcanic rocks. Dr. Fownes detected its presence in igneous rocks

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* I cannot refrain from inserting the following humorous notice of the "Phosphate Diggins" from the *Hants Independent*:—

"ANOTHER CALIFORNIA.—A speculation has been recently entered into, and is in active operation at the back of the Island, by some enterprising individuals from the metropolis, which has been an object of extreme wonderment to the natives for these last few weeks, more particularly to those who reside near the spot in question; and if the object sought for by these parties, much of which has already been obtained, is not rich in the precious metal which distinguishes the quartz of California, they must entertain the idea of speedily transmuting it into gold, if they intend to defray the immense cost of procuring it. In order to enlighten our readers as to the circumstances which have come to our knowledge relating to this matter, we must remind them that on the edge of the High Uppercliff, which extends from Blackgang to Ventnor, there creeps out at intervals a stratum of fossils; one of these, situate exactly over that wild-looking spot at the back of the celebrated Chalybeate spring, has been long known to the fishermen on the coast as abounding in the most perfect specimens, but excepting a pecuniary reward for the discovery of an extraordinary antediluvian monster from some curious geologist, it was never imagined or suspected that it possessed the slightest monetary value as an article of commerce. Such, however, proves to be the fact, if we may judge of the labour which is engaged to procure it. Some scientific explorer of our island treasures having carried back with him to London a specimen of these fossils, an analysis of their component parts warranted the expenditure of vast sums of money in order to procure more; and for the last three weeks great numbers of labourers, their wives and children, have been employed daily, the former in removing the upper soil and digging up the required material, the latter in picking and sifting it, preparatory to its being exported, for which preparations of all ages, and was so struck with its occurrence in ancient lavas, &c., that he remarked: "It cannot be devoid of interest to trace to its *first source* the enormous quantity of phosphoric acid, now for the most part locked up in a temporarily insoluble condition in the vegetable and animal kingdoms, and in the various strata of calcareous and

are now making. The article for which they are searching is chiefly composed of fossil ammonites, and the veins of strata in which they lie are from one to three feet in thickness. The shells themselves vary in size from the dimensions of a hazel-nut to the diameter of a common dinner-plate, but we saw a specimen dug from this spot not long since which was as large as the top of a tea-table. The most perfect shells are preserved for the cabinets of the curious; the broken pieces, which now amount to several tons weight, are carefully separated from the extraneous matter, and placed by themselves in a heap ready for exportation. The spot is strictly guarded, not only on the working days, but more particularly on the Sabbath. The utmost secrecy is observed by the principals as well as the overlookers, as to the use to which it is intended to apply the collection, and no interrogations whatever can elicit a satisfactory answer. When the ‘diggins’ first commenced, this singular stratum ‘cropped out’ near the surface, and was easily to be procured, but as the labourers proceed further into the side of the hill, they are obliged to remove the upper crust of loam and limestone, which is from six to ten feet in thickness, before they can arrive at the fossil strata. The land is in the possession of Mr. William Henry Dawes, and we are informed that the parties have agreed to pay him £30 per acre for liberty to turn over the surface and extract the fossils! We have been informed that this same stratum extends to Ventnor, and shows itself on Bembridge Down. We have not yet met with a practical chemist who can explain its component parts, but we suspect it will be found to contain a portion of phosphate of lime, and that it will form the principal ingredient in the manufacture of artificial manures. That it is of considerable value, no one can doubt who has witnessed the cost of procuring it; and we invite a controversy on its merits, as we cannot help feeling somewhat chagrined that this interesting discovery should have been made by utter strangers, who are likely, if there be a profit attending it, to reap the benefit thereof."

sedimentary deposits, in the formation of which organised beings have played so prominent and important a part."*

§ 17. WEALDEN FORMATION (*ante*, p. 192).—In regard to the stratigraphical phenomena of the Wealden of the Isle of Wight, no new feature has appeared in the cliffs of Sandown Bay, or in the bays to the west of Atherfield, requiring notice, except the occurrence of a stratum of soft sandstone between Atherfield and Brixton Bays, enclosing a thin layer of ironstone almost wholly made up of casts of a small species of paludina, and of one or two species of cyclas and unio. This deposit closely resembles the ferruginous sandstone with similar shells, mentioned in my "Geology of the South-east of England," as occurring at Groombridge in Sussex, and at Langton Green, near Tunbridge Wells; it may possibly hereafter assist in determining the chronological position which the Isle of Wight series should occupy in the Wealden formation.

The Wealden cliffs on the east and west of the Undercliff of the southern coast, have yielded but few additions to the flora of the country of the iguanodon; but the reptilian remains procured from these localities since my former notice equal, if not surpass, in number and interest all that I have previously collected. Through the liberality of Miss Fenwick, of Brook, Capt. Blackwood, R.N., Mr. Beckles, Sir R. Murchison, and other friends, I have obtained a most instructive series of vertebræ, and other bones, not only of the iguanodon, cetiosaurus, streptospondylus, goniopholis, &c., but of equally gigantic, and hitherto unknown or undescribed saurians. Many specimens were procured with much labour from the cliffs, when first exposed by a recent slip of the strata, and were thus preserved from that destruction of their processes and articulating surfaces, which takes place from exposure on the sea-shore; I have, consequently, succeeded in developing

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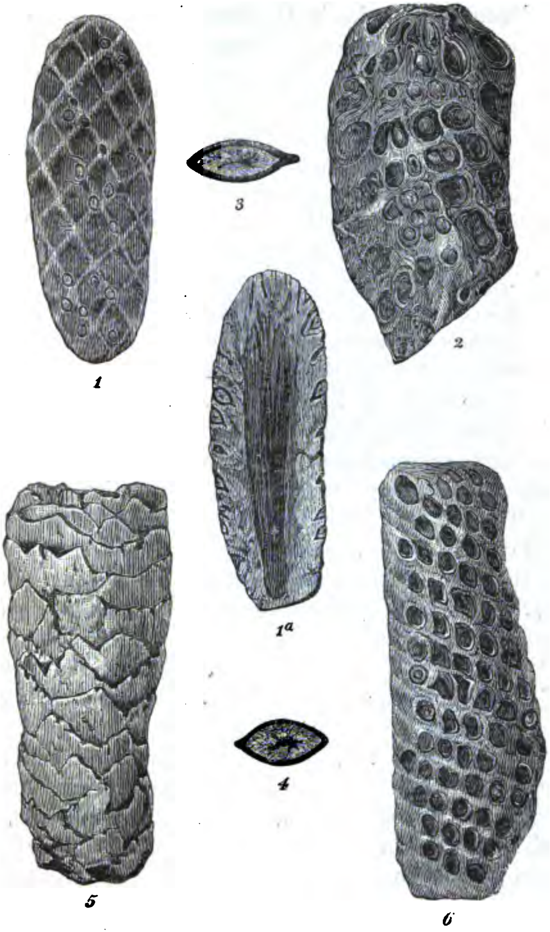
* Dr. Fownes, on the "Presence of Phosphoric Acid in Rocks."



LIGN. 42—FIR-CONES, FROM THE WEALDEN, ISLE OF WIGHT.—Nat. size.
(*Abietites Dunkeri, mihi.*)

Fig. 1.—A waterworn specimen, exposing the receptacles of the seeds.
1*a*.—Vertical section of the same, showing the axis, scales, and seeds.
2.—Partially abraded, so as to display many seeds in their cells.

Figs. 3 and 4.—Longitudinal sections of two seeds, showing the dark carbonaceous pericarp, the substance of the seed transmuted into pyrites, and a central cavity lined with spar; the figures are enlarged.

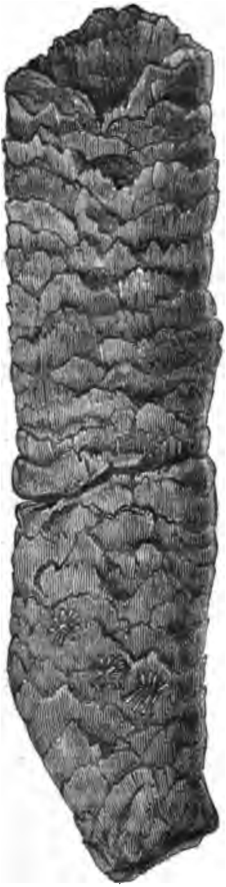
5.—Portion of a cone in which the expansions of the scales, more or less mutilated, remain, and conceal the cells and seeds.

6.—An example in which the scales have been so much worn away by attrition, that the cells, with some seeds *in situ*, are beautifully exhibited. All the specimens are somewhat compressed.

several enormous vertebræ in a more entire state than any before obtained. I subjoin a cursory notice of a few of the most interesting Wealden fossils that have been recently collected.

§ 18. FIR-CONES, FROM THE WEALDEN.—When the former edition of this work was published, a fragment of a fir-cone from Sandown Bay, and two or three rolled specimens, apparently of the same species, from Brook, were the only remains of the fruits or seed-vessels of the Wealden coniferous trees, that had come under my notice. Within the last few months I have obtained a considerable number of cones from the pyrites, collected by the fishermen from the cliffs to sell for "copperas;" and although I have seen no perfect example, yet in some specimens the structure of the cone, and the position of the seeds, are sufficiently displayed to afford a tolerably correct idea of the form and organisation of the original. In the annexed figures (ligns. 42, and 43,) I have delineated five specimens, all of which are more or less waterworn, but exhibit in their different states of abrasion, the scales, the disposition and spiral arrangement of the receptacles, and the seeds themselves. In lign. 43, is represented a more perfect example of the appearance of the cone with the scales, and their foliated expansions, which, though mutilated, are not worn away so as to expose the receptacles. The vertical section, *fig.* 1 *a*, shows the relative size of the axis and the investing scales.

These fossils are always found in a metallic state, the constituent substance consisting of pyrites and carbonaceous matter. The seeds are often exquisitely mineralised; the membranous pericarp is generally carbon; the solid part of the seed is converted into pyrites, and where a cavity has been left by the decomposition of the embryo, it is lined with calcareous spar.



LIGN. 43.—FIR-CONE, FROM BROOK BAY.—½ Nat. size.

These cones are of an elongated cylindrical form, the proportion of the length to the circumference being as 4½ to 1; the base is somewhat tapering, the summit rounded. The largest specimen I have met with is 9 inches in length. The scales are broad, slightly convex without, and concave within, thin and somewhat rounded at the points, and thicker near the axis, and, as in the cone of *Abies oblonga* of the greensand strata,* seem to have consisted of a woody central plate, deeply covered with a woolly tissue, which gave way to the pressure of the seeds. The scales appear to have had a slightly elevated midrib externally, but the perfect form and outline of the scale cannot be determined from any of the numerous specimens in my possession.

Nothwithstanding the abundance of vegetable remains in the Wealden deposits of Germany, it does not appear that any fir-cones have been observed, although the coal of the extensive Hanoverian basin is chiefly composed of the foliage and stems of firs or pines, some of the beds being nothing more than a bituminised mass of compressed needle-like leaves of coniferæ. The most abundant species (*Abietites Linkii**) has a small acicular leaf, with a slightly elevated midrib, from one to two inches long, but the foliage and small twigs bearing the cicatrices of the petioles are the only recognisable parts of the tree. I have seen in the strata at Brook Bay traces of similar leaves and stems.

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* "British Fossil Flora," p. 137.

These cones unquestionably belong to the coniferous trees composing the drifted forest or raft at Brook, (see pp. 204—208,) and we have, therefore, at length acquired sufficient knowledge of the form and structure of the wood, trunk, branches, foilage, and fruit, to enable the accomplished botanist to reconstruct and delineate the pine-forests that must have extended over vast tracts of the country of the iguanodon, and have constituted an important feature in its flora.

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* Dr. Dunker's "Monograph on the Wealden of North Germany," tab. ix. fig. 11 ("Monographie der Norddeutschen Wealdenbildung. Braunschweig, 1846"), which is thus described :—"ABIETITES (*Abies*) LINKII (*Römer*), rather thick, linear, leathery leaves, narrow at the base, and truncated at the point, traversed by a median nerve, which gradually becomes less distinct upwards; on the under side of the leaf the midrib is distinct only towards the base. The upper surface is usually from the base upwards covered with very fine transverse folds or wrinkles, as if from the shrinking and corrugation of the parenchyma. Most of the leaves are of a dark brown colour, and are glossy, transparent, and flexible, being but imperfectly carbonised. They are found associated with cypress twigs, pterophyllum Lyellianum, and remains of other plants, in the slaty and foliated coal at Duingen, as well as at Diester and Osterwalde, and are compressed together in such extraordinary quantities, that those beds of coal are almost exclusively formed of them. It is not rare to find small branches distinctly marked with the scars left by the removal of the petioles. M. Römer has observed the oval ripened scales of fir-cones."—"Mon. Nord. Weald." pp. 18, 19.

It is with great pleasure that I record my sense of the high value of the researches of Dr. Dunker, of Hesse Cassel, the diligent and successful explorer of the Wealden of North Germany, by naming this species of fossil cone, *Abietites Dunkeri.*[*]

Several fragments of stems of clathraria and endogenites have been obtained from Sandown Bay, but they afford no additional information respecting the structure of the original plants.

§ 19. WEALDEN REPTILES (*ante*, p. 225).—So numerous and gigantic are the specimens obtained by myself and others in the course of the last two years, that the account given in a previous chapter of the abundance and magnitude of the reptilian remains washed out of the cliffs along the southern shores of the Island by the continual encroachments of the sea, so far from being an exaggerated statement, as some authors have supposed, conveys but a faint idea of the numbers and colossal proportions of the bones of terrestrial and aquatic saurians contained in the Wealden deposits.

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[*] There are now at least six well-defined species of coniferous fruits that may be referred to the British Wealden and cretaceous flora, viz.—

Abietites[a] Benstedi, *mihi*, greensand, with iguanodon remains, Maidstone.
——— Dunkeri, *mihi*, Wealden of Isle of Wight.
——— oblongus, *Lindley*, greensand of Dorsetshire.
Pinites Fittoni, *mihi*, Wealden of Tilgate Forest.[b]
——— Sussexiensis, *mihi*, greensand of Sussex.
Zamites crassus, *Lindley*, Wealden of Isle of Wight.

[a] The provisional generic term, *Abietites*, is adopted in conformity with the nomenclature of M. Göppert.

[b] This remarkable cone, (figured and described by Dr. Fitton, Geol. Trans. vol. iv. Pl. XXII. fig. 10,) which is characterised by the double prominences on the scales, is probably more nearly allied to pinus than to abies. It will be convenient to affix a specific name, and I propose that of *Fittoni*, as a tribute of respect justly due to one of the most eminent British Geologists.

To particularise only those in my possession would require more space than the limits of this volume will admit, and it must suffice to mention that since my former description of the known bones of the skeleton of the iguanodon, there have been discovered fine specimens of the humerus, femur, tibia, several cervical, dorsal, and caudal vertebræ, proximal metatarsals and ungueals, portions of two lower jaws, and a fragment of the upper jaw with seven teeth in their natural position.

One of the most interesting specimens I have seen is from Brixton Bay;* it consists of a considerable part of the spine of a very young iguanodon imbedded in a block of white sandstone, the bones being, as usual, of a dark colour, from an impregnation of iron. There are thirteen or fourteen dorsal vertebræ in a continued series, and although most of these bones are destitute of the neural arch and lateral processes, yet a good idea of the structure of that part of the vertebral column is presented. There are three or four cervical vertebræ detached from the block: and portions of several ribs, some of which lie upon a thin black substance, with a shagreen surface, apparently the remains of the dermal integuments. A considerable number of the phalangeal and metatarsal bones of the left foot are imbedded in close apposition, the plantar aspect lying uppermost, and though much crushed, their agreement with the corresponding parts in the Maidstone iguanodon, and other adult examples, is very obvious. There are also several other bones, some of which are probably tarsals, but these are too obscured by the investing sandstone to admit of definition in the present state of the specimen.

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* Now in the possession of J. S. Bowerbank, Esq., to whom I am indebted for the loan of it.

Of several large reptiles, whose aquatic, and probably marine, habits, may be safely inferred from the characters of the bones of the extremities, there are in my possession vertebræ, and phalangeal and ungueal bones, that probably belong to the genus cetiosaurus; yet there is some difficulty even in determining the generic relations of these remains, for there are several anchylosed vertebræ, apparently portions of a sacrum of the dinosaurian type, which unquestionably belong to the same individual as the so-named cetiosaurian vertebræ.

A scapula, 26 inches long, and 12 inches wide, found with several enormous vertebræ, and portions of two anchylosed bones, apparently the radius and ulna, bear much resemblance to those of the dugong; the extreme solidity of the bones of the fore-arm, with the absence of a medullary cavity, at once distinguishes them from those of the terrestrial saurians with which they are associated. From the essential difference existing in the characters of certain convexo-concave vertebræ lately obtained, it is evident that this modification of the bones composing the anterior part of the spinal column was not, as some eminent authors have supposed, restricted to one genus,* but existed in several genera of the extinct saurians of the Wealden.

It is not a little remarkable that no teeth have been found that can be assigned to these colossal animals; those of the iguanodon, megalosaurus, and hylœosaurus, and the common crocodilian type, as goniopholis, teleosaurus, suchosaurus, &c., are the only forms I have procured, or have recognised in the collections of my scientific friends. It is highly probable that some modification of the conical, striated, vertically successional teeth, so prevalent a form in the crocodilian reptiles of the oolite, may have characterised the dental organs of some of the imperfectly known gigantic saurians of the Wealden; at present I am not aware of any teeth even of this type that can be referred to them; the discovery of teeth and jaws with other parts of the skeleton, can alone afford a solution of the problem.

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* Streptospondylus, of H. Von Meyer.

§ 20. PURBECK STRATA (*ante*, p. 255).—On the palæontological characters of the strata composing the lowermost series of the Wealden formation—the Purbeck—an interesting memoir was communicated a short time since to the British Association at Edinburgh by Professor Edward Forbes, of which the following is an abstract:*—The strata examined were those exposed along the coast from Swanage to Weymouth. Professor Forbes conceives that the Purbeck series may be divided into three natural groups, each with its peculiar assemblage of organic remains, and that the lines of demarcation between them are not the result of physical or mineral change in the deposits. The lithological features which attract the eye, such as the dirt-beds, the dislocated strata at Lulworth, and the cinder-bed, do not indicate any breaks in the distribution of organised beings. The causes which led to a complete change in the organic forms three times during the deposition of these freshwater and brackish strata must be sought for, not simply in a rapid or sudden change of their area into sea or land, but in the great lapse of time which intervened between the periods of their deposition. A most remarkable feature in the molluscous fauna of the Purbeck is the similarity between the generic forms and those of tertiary freshwater strata, and existing genera; and this resemblance is so great, that had we only such fossils before us, and no evidence of the position of the rocks in which they occur, we should be wholly unable to assign them a definite geological epoch. From a comparison of the fossils with those collected from the Hastings sands and Weald clays, Professor Forbes considers the fauna of the middle and upper Wealden series as entirely distinct, so far as species of mollusca are concerned, from those of the lower or Purbeck division. Some of the species reputed identical prove to be distinct; and others are derived from certain strata near Tunbridge, which Professor Forbes supposes may belong to the Purbeck.* This he conceives to be confirmed by the Wealden of the north of Germany, the fauna of the upper part of which corresponds with our Wealden, and that of the lower series with the Purbeck.

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* The result of an examination of the Purbeck coast during a residence at Swanage in the course of the summer of 1850.

But the most extraordinary fact described in this communication is, that the Purbeck freshwater mollusca and cyprides differ less from living British species than the latter do from those of other countries. Professor Forbes has collected between fifty and sixty species of mollusca in addition to those previously described; among them are species of physa, planorbis, and limneus, that cannot be distinguished from living forms; and with them were associated fossil seed-vessels of charæ (gyrogonites).

§ 21. RETROSPECTIVE SUMMARY.—The facts described in the preceding pages of this supplement corroborate the general inferences enunciated in a previous chapter (*ante*, p. 293), and are highly interesting and suggestive.

The fauna and flora of the eocene strata have been enriched by several species already known in the equivalent deposits of other countries, but which have only recently been discovered in the Isle of Wight, and the adjacent parts of Hampshire. Palms and club-mosses (lycopodia) are added to the fossil plants, and new species of chelonians, crocodiles, and serpents to the reptiles. The remarkable carnivorous animal, the hyænodon—previously observed only in the eocene formation of France—and three new genera of pachyderms, allied to the palæotherium and anoplotherium, have been contributed to the list of the eocene mammalia of England.

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* There does not appear to me any satisfactory proof that this supposition is correct.

To the extensive marine fauna of the chalk, have been added several new forms of mollusca, and many continental species, formerly unknown in the greensand or neocomian beds of Atherfield, have been obtained from that productive locality.

The rich flora and fauna of the lands and waters of the "country of the iguanodon" have received most important accessions. The fossil vegetables comprise specimens of clathraria, endogenites, cycadeæ, coniferæ, ferns; and, for the first time, the seed-vessels, or strobili, of the trees which occur petrified at Brook Point and other localities in England, and in a carbonised state in Hanover and the north of Germany, have been collected from the Wealden strata of the Island.

The molluscous fauna has been augmented by new species of the freshwater genera, cyclas, physa, planorbis, limneus, paludina, and unio; and of fluviatile entomostracous crustaceans, namely, cyprides and estheria. Portions of some small undescribed fishes have also been obtained; as well as several splendid examples of the well-known large species of lepidotus and hybodus, already familiar to the collector as characteristic denizens of these deposits.

The discovery of portions of two lower jaws, and of a fragment of the upper jaw, with several mature molars in their natural position, and of the humerus, scapula, coracoid, and cervical vertebræ of the iguanodon,—and of the humerus and vertebræ of a new genus of stupendous size, the pelorosaurus, in Tilgate Forest; and of various parts of the skeleton of other gigantic saurians, whose generic characters and relations are not defined,—are treasures so rich and rare, as to offer the highest encouragement to the diligent explorer of the Wealden deposits of the South-east of England.

No certain vestiges of birds, or of the highest class of vertebrata, the mammalia, have as yet been discovered, either in the chalk or Wealden formations; but the Stonesfield beds have yielded one more specimen of the lower jaw of the small warm-blooded quadrupeds, whose fossil relics have conferred so much celebrity on those oolitic deposits, as affording the only evidence of the existence of mammalia antecedently to the eocene epoch. I still indulge the expectation that sooner or later remains of birds and mammalians will be discovered associated with those of the huge terrestrial reptiles of the Wealden; for at Stonesfield the jaws of the marsupial and insectivorous mammalia are found imbedded in blocks of stone containing teeth and bones of the Megalosaurus, the colossal saurian, whose remains occur as abundantly in the Wealden of Tilgate Forest.

With every addition to our knowledge of the organised beings that inhabited the dry land when the oolite, Wealden, and cretaceous strata were in progress of accumulation, fresh proofs are obtained that the terrestrial flora and fauna continued essentially the same from the commencement of the lowermost bed of the oolite, to the deposition of the uppermost stratum of the chalk, although the marine fauna was subjected to successive changes in the species and genera of the fishes, and of the mollusca, and other invertebrata.

Some authors have lately dwelt on the closer connection between the oolite and the Wealden, than between the latter and the chalk; apparently unaware that the general analogy, not identity, in the terrestrial organisms, was pointed out in the first work which treated of the fossils of the Wealden as constituting a peculiar group;* but we must not forget that several of the most characteristic Wealden fossils occur high up in the cretaceous series; as for example, the iguanodon, clathraria, lonchopteris, endogenites, abietites, &c.

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* "Fossils of the South Downs," p. 59; published in 1822.

Partial comparisons of this nature are but of little value. To obtain satisfactory results, the floras and faunas of the land and of the sea must be separately considered. If the organic remains of the three geological formations be contemplated under this aspect, it will be seen that while the inhabitants of the seas of the oolite and chalk, and of the rivers of the Wealden, present, in the diversity of species and genera which characterises the several groups of strata, strong lines of demarcation, the dry land was clothed with the same vegetable forms, and inhabited by the same marvellous types of reptilian organisation throughout the vast periods of time indicated by the extent and enormous thickness of these sedimentary strata. The following table will place this general accordance in a more striking point of view:—

FLORA—	*Cretac.*	*Wealden.*	*Oolite.*
Coniferæ (pines, cypresses, junipers)	*	*	*
Ferns	*	*	*
Cycadeous plants (cycadites and zamites)	*	*	*
„ Clathraria Lyellii	*	*	o
Palms (endogenites erosa)	o	*	o
Dracœna	*	*	*
FAUNA:—REPTILES—			
Pterodactyles	*	*	*
Crocodilians	*	*	*
Iguanodon	*	*	o
Megalosaurus	?	*	*
AQUATIC REPTILES—			
Chelonians (emys, trionyx, &c.)	*	*	*
Ichthyosaurus	*	*	*
Plesiosaurus	*	*	*
Cetiosaurus	o	*	*
INSECTS	o	*	*
BIRDS	o	?	o
MAMMALIA (two genera)	o	o	*

Thus the data obtained from an examination of the relics of the plants and animals imbedded in the debris of the islands and continents, brought down by fluvio-marine currents into the seas of the oolite and chalk, and by the freshwater streams and rivers into the delta and estuary of the Wealden, prove that the terrestrial fauna and flora were essentially the same throughout the geological epochs comprised in this survey.[*] Forests of pines and other coniferæ flourished contemporaneously with palms, and cycadeæ, and ferns, alike, during the deposition of the Stonesfield slate, and the arenaceous strata of the chalk.[†]

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[*] It is not meant to aver that the terrestrial species are the same throughout the oolite, Wealden, and cretaceous ages, but that the *general* characters of the fauna and flora were alike on the islands of the oolitic period, and of the chalk.

[†] The association of coniferæ (or needle-leaved trees, as the illustrious author of "Cosmos" significantly terms this family), with palms, arborescent ferns, &c., occurs in the coal formation, and throughout all the subsequent periods up to the tertiary. Humboldt remarks that we have so accustomed ourselves, although erroneously, to regard firs and pines as northern forms, that he experienced a feeling of surprise, when, in ascending from the shores of the South Pacific towards Chilpansingo, and the elevated valleys of Mexico, 4,000 feet above the level of the sea, he rode a whole day through a dense wood of *Pinus occidentalis*, and observed that these trees, which are so similar to the Weymouth pine, were associated with fan-palms (*Corypha dulcis*), and swarming with brightly-coloured parrots. Coniferæ and palms grow together on the north-eastern extremity of the island of Cuba, within the tropics, and scarcely above the level of the sea.[a] This illustrious philosopher also remarks, that if the surface of the earth did not rise to great altitudes within the tropics, the strikingly characteristic form of acicular-leaved trees would have remained unknown to the inhabitants of that zone.[b] This fact should be remembered, when attempting to explain the physical condition of the surface of the countries on which the flora of the carboniferous epoch flourished.

[a] "Cosmos," Bohn's translation.

[b] "Aspects of Nature," Bohn's translation.

Colossal herbivorous and carnivorous reptiles were the principal inhabitants of the land; pterodactyles traversed the atmosphere; aquatic reptiles swarmed in the fens and marshes; marine saurians frequented the sea-shores, and bays, and estuaries; dragon-flies sported over the waters; beetles pursued their drowsy flight, alike, when the peculiar oolitic types of mollusca, and radiaria, and zoophytes, and fishes, and crustaceans, swarmed in the surrounding ocean, as in the cretaceous period, when most of the genera and species had died out, and other forms occupied their place in the system of nature.

From these, and innumerable facts of a like character, we perceive that the idea once generally entertained that the extinction of species and genera had been occasioned by physical revolutions and catastrophes, assumed to have swept over the earth's surface, must now be abandoned. Successive mutations in species and genera appear to be the result not of physical but organic laws; the first appearance, the duration, and the persistence of any type of organisation, are determined by laws as inscrutable, but as certain and immutable, as those which govern the revolutions of the sidereal universe; and as the period of life and death of every individual of a particular species of animal and plant is irrevocably preordained, so also is that of the annihilation of the race to which it belongs.

And here I must conclude this sketch of the palæontological discoveries that have been brought under my notice since the original publication of this work, and bid farewell to the COURTEOUS READER, who has accompanied me in these Excursions through the Isle of Wight, and along the adjacent coasts of Hampshire and Dorsetshire.

DESCRIPTION OF THE GEOLOGICAL MAP OF THE ISLE OF WIGHT.

To render this map instructive to the general reader, it may be necessary to explain the principle on which geological charts are constructed. The intelligent observer is of course aware that the surface of every country is more or less covered by vegetable soil, and that beneath this superficial layer of earth there are beds of loam, clay, sand, gravel, &c., of various thickness and extent, which often abound in boulders and large waterworn masses of stone, derived either from the strata of the surrounding district, or from the rocks of distant countries, and have been transported at some remote period to their present situation; they frequently contain bones of extinct species of elephant, horse, ox, deer, &c. These accumulations of alluvial detritus were formerly distinguished by the general name of *Diluvium*, or diluvial deposits, and their formation was ascribed to the effects of an universal deluge; but they are now called "*Drift*," a term significant of their origin from aqueous or glacial transport. (See *ante*, p. 40.)

These heterogeneous deposits are distributed over the fundamental strata of the country, which they conceal from observation, except where the latter are exposed to view by natural sections—as sea-cliffs, ravines, and precipitous escarpments—or by artificial openings, as quarries, railway works, well-sinkings, &c. The geographical distribution of the *regular deposits* beneath the superficial drift and vegetable earth is indicated by the colours on the map; the section from West Cowes across the Island to the Undercliff, shows the order of succession of the three groups of strata composing the Isle of Wight (*ante*, p. 41); or, in other words, the manner in which these have been deposited upon each other. This order of superposition determines the chronology or relative antiquity of each formation, for it is obvious that the lowermost beds must be more ancient than those which lie upon them. The strata, though originally deposited in horizontal layers, are now more or less inclined, in consequence of the subterranean disturbances which have taken place since their original deposition and consolidation; hence the varied aspect of the physical geography of the district.

The geological map is intended to demonstrate the order and succession of the principal groups of deposits, and the lithological structure of the rocks distributed over a given area, and the nature of the organic remains they may contain. The three natural groups or formations composing the Isle of Wight are expressed by distinct colours. Thus the WEALDEN beds are indicated by the *sienna* tint, the CRETACEOUS by *blue*, and the TERTIARY or EOCENE by *pink:* the subdivisions are defined by lines of shading. The following summary of the characters of the several formations described in the body of the work, will enable the tourist to comprehend at a glance the geological phenomena of the Island.

I. THE WEALDEN (*ante*, p. 197). This formation consists of an extensive series of clays, sands, sandstones, and limestones, the aggregated thickness of which is upwards of 1,000 feet. The strata are characterised by the abundance of univalve and bivalve shells, and minute crustaceans, of species that exclusively inhabit rivers, lakes, and pools of freshwater. With these are associated bones, teeth, and scales of marine and fluviatile fishes; and the bones and teeth of gigantic terrestrial and aquatic reptiles; and the stems, foliage, and fruit of pines, firs, cypresses, cycadeous plants, ferns, and other land vegetables. But few vestiges of marine plants and animals have been observed.

The line of cliffs extending from the west of Atherfield Point to near Compton Bay, and that from Redcliff in Sandown Bay to the Fort (coloured *sienna* on the map), are natural sections of the Wealden deposits; and along the shores in these localities bones of enormous extinct reptiles are continually exposed by the encroachments of the sea on the wasting cliffs.

II. The CRETACEOUS OR CHALK FORMATION (*ante*, p. 126), comprises the strata which overlie and conceal the Wealden, and constitute the southern half of the Island, as shown by the *blue* colour. The lowermost series (*the greensand*) consists of sands and clays, with bands of cherty limestone; above this group is a thick bed of stiff blue marl or clay, termed *galt*, or *Folkstone marl*; on this are strata composed of marl, with an intermixture of particles of green silicate of iron, the consolidated layers of which constitute the limestone provincially called *firestone*, a term now generally employed by geologists to designate these arenaceous marly deposits. The uppermost series of the cretaceous system consists of strata of white limestone, composed of the substance generally known as chalk, with layers and nodules of flint. The four subdivisions of this extensive formation, namely, the lower greensand, galt, firestone, and chalk, amount in aggregate thickness to nearly 1,500 feet. They are severally expressed on the map by different lines of shading.

The fossils of the cretaceous system are entirely marine, with the exception of a few vestiges of terrestrial reptiles and plants, analogous to those of the Wealden. They consist of many hundred species of extinct genera of bivalves and univalves, and of corals and other zoophytes; of crustaceans, star fishes, crinoideans, sea-urchins, and numerous fishes. The subdivisions of the formation are characterised by peculiar fossils; but throughout the entire system there is a general resemblance in the predominating types of animal and vegetable forms, showing that the various strata were deposited in the basin of the same ocean, and under like physical conditions. From the variable composition of the cretaceous strata much diversity has been imparted to the geographical features of the tracts they occupy. The picturesque character of the bold escarpments produced by the disrupted masses of the upper chalk is displayed in the beautiful sketches of Freshwater Bay in "Barber's Illustrations of the Isle of Wight," p. 92, and of Scratchell's Bay and the Needles (*ibid.* p. 97). The charming effect occasioned by the degradation of the cliffs of the lower greensand deposits, is exemplified in the views of Blackgang Chine (*ibid.* p. 83), and Shanklin Chine (*ibid.* pp. 64, 66); and the lovely scenery to which the faults and slips of the firestone and galt strata have given rise, is shown by that part of the southern coast known as "THE UNDERCLIFF," and delineated in the sketches of Bonchurch, Ventnor Cove (*ibid.* p. 77), and Puckaster Cove (*ibid.* p. 80); while the fine chain of Downs, rising in many places to an altitude of 800 or 900 feet, exhibits the usual features of the smooth rounded masses intersected by gentle valleys, so characteristic of the mountain ranges of the white chalk strata. St. Boniface Down (*ibid.* p. 73), and the sketch of the Down behind Carisbrook Castle (*ibid.* p. 47), are examples of this scenery.

III. The EOCENE, or *Ancient Tertiary System* (*ante*, p. 55).—The strata above the chalk extend over the northern half of the Island. They are subdivided into two groups; the lowermost consists chiefly of clays, with alternations of layers of sand, gravel, loam, &c., abounding in marine shells, crustaceans, fishes, &c., of extinct species, and distinct from any that have been observed in the cretaceous strata on which these beds are superposed. This group is commonly designated the *London Clay*, because the strata and fossils correspond in character with those on which the metropolis is situated. It extends from White Cliff Bay on the eastern extremity of the Island, along the northern flank of the Chalk Downs to the well-known cliffs of Alum Bay.

The upper tertiary series consists of sands, clays, and bands of good building limestone, abounding in freshwater shells and vegetables, many of the layers are composed of various kinds of lacustrine snails and aquatic plants, consolidated by an infiltration of carbonate of lime. In these deposits bones and teeth of extinct mammalia allied to the tapir, peccary, (*ante*, p. 115,) &c., and bones of crocodiles and turtles, are occasionally found. These strata form the northern coast of the Island; their extent is indicated on the map by the unshaded *pink* tint.

The scenery of the tertiary strata, though less bold than that of the tracts formed by the chalk, is in many localities eminently beautiful; the gentle valleys and sequestered dells and coves dispersed here and there over the northern district and along its shores, imparting a charming variety to the landscape. Brading, Bembridge, Ryde, Cowes, her Majesty's Marine Residence, and Yarmouth, are situated on these deposits.

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